MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

VOL. LXIII. FEBRUARY 13, 1903. No. 4

ANNUAL GENERAL MEETING.

E. B. KNOBEL, Esq., VICE-PRESIDENT, in the Chair.

The Report of the Auditors of the Treasurer's accounts for the year 1902 was read, and is given on p. 182.

The Annual Report of the Council was read ; see pp. 179 to 280.

The Address was delivered by Professor H. H. Turner, D.Sc., F.R.S., after which the Gold Medal was handed to Count von Bernstorff, the Councillor of the German Legation, for transmission to Professor Hermann Struve, to whom the Medal had been awarded for his work on the Satellites of *Saturn*.

The following alteration of Bye-Law 23, which had been proposed by the Council, was brought forward by the Treasurer : That the Composition fee be raised to thirty guineas, and be reduced by one guinea each year after five years to a minimum of five guineas, and that Bye-Law 23 be altered accordingly. After a discussion the motion was put to the meeting and carried, the Bye-Law as altered reading as follows :

23. Any Fellow may, at his entrance, compound for his contributions by the payment of thirty guineas, exclusive of his Admission fee ; or he may at any time afterwards in the ensuing five years (all sums then due being first paid) compound for his *subsequent* annual contributions by a like payment of thirty guineas. After the first five years the Composition fee will be reduced by one guinea for each year of Fellowship in excess of five years, to a minimum fee of five guineas, under the same conditions.

The Society then proceeded to the ballot for Officers and Council for the ensuing year, the names of those elected being given on p. 291.

The thanks of the Meeting were given to the retiring Members of Council and also to the Auditors of the Treasurer's Accounts and the Scrutineers of the Ballot.

Thomas Ayres, M.Sc. (Vict.), Finkmattstrasse 7, Strassburg, Germany ;
Charles William Keighley, Cluny Villa, Burlington Lane, Chiswick ; and
Henry Norris Russell, Oyster Bay, New York, U.S.A.,

were balloted for and duly elected Fellows of the Society.

The following Candidates were proposed for election as Fellows of the Society, the names of the proposers from personal knowledge being appended :—

Thomas Frederick Bowers, B.A., Head Master, Woolwich Polytechnic School, and "Darenth," Little Heath, Old Charlton, S.E. (proposed by J. E. Evans) ;
Frederick Hugh Capron, solicitor, "Polaris," 38 Avenue Road, Highgate N. (proposed by the Rev. P. H. Kempthorne) ;
Kenneth Essex Edgeworth, Lieut. R.E., Stanhope Lines, Aldershot (proposed by W. E. Wilson) ;
Alphonso King, Elementary Teacher, 93 Victoria Road East, Leicester (proposed by Walter E. Besley) ;
William Tillar, Board of Trade Surveyor, St. Kilda's, Westbourne Road, West Kirby (proposed by M. J. O'Sullivan) ;
Gilbert Thomas Walker, Assistant Reporter in Meteorology to the Government of India, Trinity College, Cambridge, (proposed by H. H. Turner) ; and
Pollard Wilkinson, B.A., B.Sc. (Lond.), Schoolmaster, 21 Ashmere Grove, Ipswich (proposed by Alfred H. Fison).

Report of the Council to the Eighty-Third Annual General Meeting of the Society.

The following table shows the progress and present state of the Society :—

	Compounders	Annual Subscribers	Total Fellows	Associates	Patron	Grand Total
1901 December 31	250	375	625	46	1	672
Since elected	+ 5	+31	...	...	...	...
Deceased	...	−10	...	− 2	...	...
Resigned	...	−11	...	...	...	...
Removals	+ 2	− 2	...	...	...	...
Expelled	...	...	...	...	...	...
1902 December 31	257	383	640	44	1	685

Mr. Maw's Account as Treasurer of the Royal

RECEIPTS.

	£ s. d.	£ s. d.
Balances, 1902 January 1:—		
At Bankers', as per Pass-book	101 8 4	
„ on deposit	300 0 0	
In hand of Assistant Secretary on account of Turnor and Horrox Fund...	6 9 3	
		407 17 7
Dividends on £1,250 Metropolitan 3-per-cent. Stock	35 4 1	
Dividends on £932 19 0 Metropolitan 2½-per-cent. Stock	21 17 10	
Dividends on £3,400 East Indian Railway 3-per-cent. Debenture Stock	95 14 6	
Dividends on £3,200 London and North-Western Railway 3-per-cent. Debenture Stock	90 6 0	
Dividends on £4,000 Midland Railway 2½-per-cent. Debenture Stock	94 1 3	
Dividends on £1,860 Gas Light and Coke Co. 3-per-cent. Debenture Stock	52 9 8	
Dividends on £1,100 Commercial Gas Co. 4½-per-cent. Debenture Stock	46 9 2	
Interest on £300 on Deposit at Bankers'	5 9 8	
		441 12 2
Received on account of Subscriptions:—		
Arrears	130 4 0	
Annual Contributions for 1902	604 16 0	
„ „ 1903	4 4 0	
Admission Fees	73 10 0	
First Contributions	49 7 0	
		862 1 0
Composition Fees		147 0 0
Sales of Publications:—		
At Williams and Norgate's, 1901	13 16 4	
At Society's Rooms, 1902	52 1 2	
Sales of Photographs, 1902	17 14 6	
		83 12 0
Received from Mr. H. C. Russell towards cost of reproducing plates in *Monthly Notices* ...		3 0 0
Income Tax refunded by Commissioners of Inland Revenue		26 8 9
Cheques outstanding 1902 December 31		16 19 6
Due to Assistant Secretary on Petty Cash Account	1 17 2	
„ „ on account of Turnor and Horrox Fund	0 4 7	
		2 1 9
		£1,990 12 9

Examined and found correct, 1903 Jan. 8:
H. P. Hollis, F. W. Levander, W. J. S. Lockyer.

Astronomical Society, from 1902 *January* 1 *to December* 31.

EXPENDITURE.

	£	s.	d.	£	s.	d.
Assistant Secretary: Salary	250	0	0			
,, ,, for assistance in editing Society's Publications ...	50	0	0			
				300	0	0
House Duty	2	12	6			
Fire Insurance	9	9	6			
				12	2	0
Printing, plates, &c., *Monthly Notices* (Spottiswoode & Co.)	455	5	5			
Photo-engraving Plates in *Monthly Notices* (Dent & Co.)	5	8	9			
Plates for *Memoirs* (Adams MSS.) (Dent & Co.) ...	31	10	0			
Printing, &c., Appendix to *Memoirs* (Harrison & Sons)	61	2	0			
Plates for Appendix to *Memoirs* (London Stereoscopic Co.)	14	7	6			
Printing, Appendix to *Monthly Notices* (Harrison & Sons)	19	12	6			
Printing, List of Fellows and Miscellaneous (Spottiswoode & Co.)	24	16	6			
				612	2	8
Computation of Ephemerides in *Monthly Notices* ...				15	0	0
Turnor and Horrox Funds: Purchases for Library	21	13	10			
Binding books in Library	47	2	9			
				68	16	7
Reproduction of Photographs				16	0	2
Cataloguing astronomical literature for the International Catalogue of Scientific Literature ...				30	0	0
Clerk's Wages	52	0	0			
Postage and Telegrams	71	15	9			
Carriage of Parcels, &c.	4	17	2			
Stationery (Spottiswoode & Co.)	4	9	6			
Sundry Stationery and Office Expenses	6	14	9			
				139	17	2
Expenses of Meetings	19	8	0			
Lantern Expenses	10	12	0			
Time Signal, &c.	5	0	0			
				35	0	0
House Expenses	63	0	11			
Coals and Gas	58	10	11			
Electric Light Expenses	6	6	4			
Sundry Repairs, Fittings, &c.	22	16	8			
Sundries	5	14	4			
				156	9	2
Engrossing, &c., Addresses to Glasgow University and Owens College, Manchester	5	16	0			
Contribution to cost of illuminating, &c., the front of Burlington House, 1902 August 9	15	0	0			
				20	16	0
Jackson Gwilt Gift to Dr. T. D. Anderson ...				25	0	0
Deductions on Cheques, &c....					3	0
Repayment to Assistant Secretary of amount due 1901 Dec. 31 on Petty Cash Account... ...				1	19	3
Cheques outstanding, 1901 Dec. 31				16	19	6
Balances, 1902 December 31:—						
At Bankers', as per Pass-book	231	16	9			
Country Cheque not credited till 1903 ...	8	10	6			
At Bankers', on deposit	300	0	0			
				540	7	3
				£1,990	12	9

Report of the Auditors.

We have examined the Treasurer's accounts of receipts and expenditure for the year 1902, and have found and certified the same to be correct. The cash in hand on December 31, 1902, including the balance at the bankers', &c., amounted to 540*l.* 7*s.* 3*d.*

The invested property of the Society is the same as at the end of the previous year.

The books, instruments, and other effects in the possession of the Society have been examined, and they appear to be in a satisfactory condition.

We have laid on the table a list of the names of those Fellows who are in arrear for sums due at the last Annual General Meeting of the Society, with the amount due against each Fellow's name.

We wish to repeat our recommendation of last year that the amount of the composition fee should be increased, and we suggest further that the number of annual contributions previously paid should be taken into account in fixing the amount in the case of the present Fellows.

We think that, as a matter of account, the amount received for composition fees should not appear as annual income, but that a Capital Account should be kept in which these amounts should be exhibited.

(*Signed*) H. P. Hollis.
F. W. Levander.
W. J. S. Lockyer.

1903 *January* 8.

Trust Funds.

The Turnor Fund: A sum of £464 18*s.* East Indian Railway 3-per-cent. Debenture Stock; the interest to be used in the purchase of books for the Library.

The Horrox Memorial Fund: A sum of £103 6*s.* East Indian Railway 3-per-cent. Debenture Stock; the interest to be used in the purchase of books for the Library.

The Lee and Janson Fund: A sum of £334 10*s.* 9*d.* East Indian Railway 3-per-cent. Debenture Stock; the interest to be given by the Council to the widow or orphan of any deceased Fellow of the Society who may stand in need of it.

The Hannah Jackson (née Gwilt) Fund: A sum of £309 18*s.* 6*d.* East Indian Railway 3-per-cent. Debenture Stock; the interest to be given in Medals or other awards, in accordance with the terms of the Trust.

Assets and Present Property of the Society, 1903 January 1.

	£	s.	d.	£	s.	d.
Balances, 1902 December 31:—						
At Bankers', as per Pass-book	231	16	9			
Cheque not credited till 1903	8	10	6			
At Bankers' on deposit	300	0	0			
	540	7	3			
Less due to Assistant Secretary on Petty Cash Account and Turnor and Horrox Fund Accounts £2 1 9						
Less Cheques outstanding ... 16 19 6						
	19	1	3			
				521	6	0
Due on account of Subscriptions:—						
3 Contributions of 4 years' standing	25	4	0			
7 „ 3 „	44	2	0			
28 „ 2 „	117	12	0			
64 „ 1 „	134	8	0			
1 Admission Fee and First Contributions ...	3	3	0			
	324	9	0			
Less 2 Contributions paid in advance ...	4	4	0			
				320	5	0
Due for Photographs sold	...		...	0	13	0
Due from Messrs. Williams and Norgate for sales of Publications during 1902				7	13	11
£3,400 East Indian Railway 3-per-cent. Debenture Stock, including the Turnor Fund, the Horrox Memorial Fund, the Lee and Janson Fund, and the Hannah Jackson (née Gwilt) Fund.						
£3,200 London and North Western Railway 3-per-cent. Debenture Stock.						
£4,000 Midland Railway 2½-per-cent. Debenture Stock.						
£1,860 Gas Light and Coke Co. 3-per-cent. Debenture Stock.						
£1,100 Commercial Gas Company 4½-per-cent. Debenture Stock.						
£1,250 Metropolitan 3-per-cent. Stock.						
£932 19 0 Metropolitan 2½-per-cent. Stock.						
Astronomical and other Manuscripts, Books, Prints, and Instruments.						
Furniture, &c.						
Stock of Publications of the Society.						
Four Gold Medals.						

Stock in hand of volumes of the *Memoirs*:—

Vol.	At Society's Rooms	At Williams & Norgate's	Vol.	At Society's Rooms	At Williams & Norgate's
I. Part 1	8	...	XXXI.	113	...
I. Part 2	42	...	XXXII.	125	...
II. Part 1	51	3	XXXIII.	133	...
II. Part 2	16	3	XXXIV.	136	...
III. Part 1	65	1	XXXV.	83	...
III. Part 2	82	1	XXXVI.	165	8
IV. Part 1	77	3	XXXVII. Part 1	310	7
IV. Part 2	89	3	XXXVII. Part 2	258	8
V.	72	3	XXXVIII.	244	1
VI.	90	6	XXXIX. Part 1	209	2
VII.	112	3	XXXIX. Part 2	212	2
VIII.	97	3	XL.	224	1
IX.	102	3	XLI.	365	1
X.	115	...	XLII.	207	3
XI.	120	...	XLIII.	203	...
XII.	124	...	XLIV.	186	1
XIII.	120	...	XLV.	219	...
XIV.	330	...	XLVI.	195	2
XV.	105	...	XLVII. Part 1	2	...
XVI.	130	1	XLVII. Part 2	18	...
XVII.	117	1	XLVII. Part 3	2	...
XVIII.	109	1	XLVII. Part 4	8	...
XIX.	119	...	XLVII. Part 5	8	...
XX.	109	1	XLVII. Part 6	9	...
XXI. Part 1	244	...	XLVII.	190	1
XXI. Part 2	98	...	XLVIII. Pt. 1	222	1
XXI.	31	...	XLVIII. Pt. 2	223	1
XXII.	131	...	XLIX. Part 1	348	2
XXIII.	116	...	XLIX. Part 2	234	2
XXIV.	126	1	L.	221	2
XXV.	129	...	LI.	248	...
XXVI.	139	1	LII.	283	2
XXVII.	394	1	LIII.	290	2
XXVIII.	351	...	LIV. App. I.	582	...
XXIX.	374	1	App. II.	622	...
XXX.	126	1	App. III.	684	...
			Index to *Memoirs*	607	2

Stock in hand of volumes of the *Monthly Notices*:—

Vol.	At Society's Rooms	At Williams & Norgate's	Vol.	At Society's Rooms	At Williams & Norgate's
I.	52	...	XXXIII.	86	...
II.	54	...	XXXIV.	65	1
III.	...	...	XXXV.	51	...
IV.	...	...	XXXVI.	25	1
V.	...	...	XXXVII.	31	3
VI.	39	...	XXXVIII.	95	2
VII.	2	...	XXXIX.	95	...
VIII.	150	1	XL.	103	3
IX.	23	3	XLI.	103	5
X.	170	1	XLII.	111	1
XI.	181	...	XLIII.	108	2
XII.	104	1	XLIV.	110	2
XIII.	176	2	XLV.	114	1
XIV.	175	3	XLVI.	107	...
XV.	167	2	XLVII.	122	2
XVI.	152	1	XLVIII.	117	...
XVII.	164	...	XLIX.	108	7
XVIII.	241	...	L.	108	9
XIX.	51	...	LI.	110	6
XX.	31	...	LII.	106	10
XXI.	16	...	LIII.	110	13
XXII.	30	...	LIV.	108	13
XXIII.	17	...	LV.	121	...
XXIV.	22	...	LVI.	119	2
XXV.	13	...	LVII.	125	2
XXVI.	9	...	LVIII.	122	...
XXVII.	3	...	LIX.	128	2
XXVIII.	70	...	LX.	132	3
XXIX.	50	...	LXI.	131	6
XXX.	61	2	LXII.	137	8
XXXI.	90	...	1st Index ...	540	1
XXXII.	106	5	2nd „ ...	788	...
Library Catalogue				538	2
„ „ Supplement				420	...

In addition to the above volumes of the *Monthly Notices*, the Society has a considerable stock of separate numbers of nearly

all the volumes. With the exception, however, of Vols. XXXVI. to LXII., no complete volumes can be formed from the separate numbers in stock.

Celestial Photographs.

The following is a list of reproductions of Celestial Photographs published by the Royal Astronomical Society for sale to the Fellows :—

R.A.S. Ref. No.	Subject.	Photographed by
1	Total Solar Eclipse, 1889 January 1	W. H. Pickering
2	Total Solar Eclipse, 1893 April 16	J. M. Schaeberle
3	Total Solar Eclipse, 1886 August 29	A. Schuster
4	Nebulæ in the *Pleiades*	Isaac Roberts
5	Nebula M 74 *Piscium* (N.G.C. 628)	Isaac Roberts
6	Great Nebula in *Orion*	Isaac Roberts
7	Milky Way near M 11	E. E. Barnard
8	Milky Way near Cluster in *Perseus*	E. E. Barnard
9	Comet *c* 1893 IV. (Brooks), 1893 October 21	E. E. Barnard
10	Comet *a* 1892 I. (Swift), 1892 April 7	E. E. Barnard
11	Nebula about η *Argûs*	David Gill
12	Portion of Moon (Hyginus-Albategnius)	Lœwy and Puiseux
13	Comet *c* 1893 IV. (Brooks), 1893 October 22	E. E. Barnard
14	Comet *c* 1893 IV. (Brooks), 1893 October 20	E. E. Barnard
15	Comet *c* 1893 IV. (Brooks), 1893 November 10	E. E. Barnard
16	Comet *a* 1892 I. (Swift), 1892 April 26	E. E. Barnard
17	Comet *f* 1892 III. (Holmes), 1892 November 10	E. E. Barnard
18	Comet *a* 1892 I. (Swift), 1892 April 18	E. E. Barnard
19	Portion of Moon (Alps, Apennines, &c.)	Lœwy and Puiseux
20	Nebula in *Andromeda*	Isaac Roberts
21	*Jupiter*, 1892 September 26	Lick Observatory
22	Cluster M 13 *Herculis* (N.G.C. 6205)	W. E. Wilson
23	Total Solar Eclipse, 1893 April 16 (5 sec.)	J. Kearney
24	Total Solar Eclipse, 1893 April 16 (20 sec.)	J. Kearney
25	The Moon (Age 7^d 3^h)	Lick Observatory
26	The Moon (Age 12^d $6\frac{1}{2}^h$)	Lick Observatory
27	The Moon (Age 16^d 18^h)	Lick Observatory
28	The Moon (Age 23^d 8^h)	Lick Observatory

R.A.S. Ref. No.	Subject.	Photographed by
29	The Sun, 1892 February 13	Roy. Obs., Greenwich
30	The Sun, 1892 July 8	Roy. Obs., Greenwich
31	Portion of Moon (Region of Maginus)	Lœwy and Puiseux
32	The Moon (Age 14^d 1^h)	Lick Observatory
33	Portion of Moon (Ptolemæus, &c.)	Lick Observatory
34	Portion of Moon (Mare Serenitatis)	Lick Observatory
35	Portion of Moon (Clavius, Licetus, &c.)	Lick Observatory
36	Portion of Moon (Regiomontanus, &c.)	Lick Observatory
37	Portion of Moon (Tycho, Thebit, &c.)	Lick Observatory
38	Portion of Moon (Theophilus, &c.)	Lick Observatory
39	Total Solar Eclipse, 1896 August 9 (3 sec.)	S. Kostinsky
40	Total Solar Eclipse, 1896 August 9 (26 sec.)	A. Hansky
41	Cluster M 56 *Lyræ* (N.G.C. 6779)	
42	Nebulæ M 81, 82 *Ursæ Majoris* (N.G.C. 3031, 3034)	
43	Cluster M 56 *Lyræ* (enlarged) (N.G.C. 6779)	
44	Solar Corona, 1871 December 12, Baikul	H. Davis
45	Solar Corona, 1875 April 6, Siam	Lockyer and Schuster
46	Solar Corona, 1878 July 29, Wyoming	W. Harkness
47	Solar Corona, 1882 May 17, Egypt	Abney and Schuster
48	Solar Corona, 1883 May 6, Caroline Island	Lawrance and Woods
49	Solar Corona, 1885 September 9, Wellington, N.Z.	Radford
50	Solar Corona, 1886 August 29, Grenada, W.I.	A. Schuster
51	Solar Corona, 1887 August 19, Japan	M. Sugiyama
52	Solar Corona, 1889 January 1, California	W. H. Pickering
53	Solar Corona, 1889 December 22, Cayenne	J. M. Schaeberle
54	Solar Corona, 1893 April 16, Fundium	J. Kearney
55	Solar Corona, 1893 April 16, Brazil	A. Taylor
56	Great Nebula in *Orion*	W. E. Wilson
57	Dumb-bell Nebula, *Vulpecula* (N.G.C. 6853)	W. E. Wilson
58	Spiral Nebula, *Canes Venatici* (N.G.C 5194)	W. E. Wilson
59	Ditto (enlarged) (N.G.C. 5194)	W. E. Wilson
60	Annular Nebula, *Lyra* (N.G.C. 6720)	W. E. Wilson
61	Meteor Trail and Comet Brooks, 1893 November 13	E. E. Barnard
62	Total Solar Eclipse, 1898 January 22 (5 sec.)	W. H. M. Christie
63	Total Solar Eclipse, 1898 January 22 (20 sec.)	W. H. M. Christie
64	Solar Corona, 1896 August 9, Novaya Zemlya	G. Baden-Powell
65	Solar Corona, 1898 January 22, Pulgaon, India	E. H. Hills
66	Nebula in *Andromeda*	Roy. Obs., Greenwich
67	Spectrum of Sun's limb, 1898 January 22	E. H. Hills

R.A.S. Ref. No.	Subject.	Photographed by
68	Annular Nebula, *Lyra* (N.G.C. 6720)	Lick Observatory
69	Dumb-bell Nebula, *Vulpecula* (N.G.C. 6853)	Lick Observatory
70	Spiral Nebula, *Canes Venatici* (N.G.C. 5194–5)	Lick Observatory
71	Spiral Nebula, *Ursa Major* (N.G.C. 5457)	Lick Observatory
72	Trifid Nebula, *Sagittarius* (N.G.C. 6514)	Lick Observatory
73	Great Nebula in *Orion*	Lick Observatory
74	Cluster M 13 *Herculis* (N.G.C. 6205)	Lick Observatory
75	Solar Surface with Faculæ	G. E. Hale
76	Faculæ and Prominences	G. E. Hale
77	Total Solar Eclipse, 1898 Jan. 22 ($\frac{2}{3}$ sec.)	W. H. M. Christie
78	Nebula H V. 14 *Cygni* (N.G.C. 6992)	W. E. Wilson
79	Portion of Moon (Theophilus, &c.)	Yerkes Observatory
80	Total Solar Eclipse, 1900 May 28 (30 sec.)	E. E. Barnard
81	Comet 1901 I., 1901 May 4	Roy. Obs., Cape of G. H.
82	Comet 1901 I., 1901 May 6	Roy. Obs., Cape of G. H.
83	Comet 1901 I., 1901 May 9	Perth Obs., W. Australia
84	Solar Surface with Faculæ	H. Deslandres
85	Solar Prominences	H. Deslandres
86	Nebula about Nova *Persei*, 1901 September 20	G. W. Ritchey
87	Nebula about Nova *Persei*, 1901 November 13	G. W. Ritchey
88	Total Solar Eclipse, 1901 May 18 (10 sec.)	F. W. Dyson
89	Total Solar Eclipse, 1901 May 18 (40 sec.)	F. W. Dyson

Nos. 44–55 and Nos. 64 and 65 form a series of corona photographs, oriented and reduced to the same scale.

The above photographs are now on sale to Fellows as prints, either platinotype or aristotype, mounted on sunk cut-out mounts, measuring 12 inches by 10 inches, and also as lantern slides. Nos. 44–55 and Nos. 64 and 65 are also supplied as transparencies, $6\frac{1}{4}$ inches square.

Price of prints, 1*s.* 6*d.* each; lantern slides, 1*s.* each; packing and postage extra.

Unmounted prints, 1*s.* each, can be obtained to order.

Transparencies, $6\frac{1}{4}$ inches square (Nos. 44–55 and Nos. 64 and 65), 3*s.* 6*d.* each.

Orders to be addressed to W. H. Wesley, Burlington House, London, W. In ordering prints or slides the R.A.S. Reference No. only need be quoted, but in the case of prints it should be stated whether platinotypes or aristotypes are required.

Instruments belonging to the Society.

A brief description of the chief instruments and other particulars relating to them will be found in *Monthly Notices*, vol. xxxvi. p. 126.

No. 1. The *Harrison* clock.
„ 2. The *Owen* portable circles, by Jones.
„ 3. The *Beaufoy* circle.
„ 4. The *Beaufoy* transit instrument.
„ 5. The *Herschel* 7-foot telescope.
„ 6. The *Greig* universal instrument, by Reichenbach and Ertel. The transit telescope, by Utzschneider and Fraunhofer, of Munich.
„ 7. The *Smeaton* equatorial.
„ 8. The *Cavendish* apparatus.
„ 9. The 7-foot Gregorian telescope (late Mr. Shearman's).
„ 10. The variation transit instrument (late Mr. Shearman's).
„ 11. The universal quadrat, by Abraham Sharp.
„ 12. The *Fuller* theodolite.
„ 13. The standard scale, by Troughton and Simms.
„ 14. The *Beaufoy* clock, No. 1.
„ 15. The *Beaufoy* clock, No. 2.
„ 16. The *Wollaston* telescope.
„ 17. The *Lee* circle.
„ 18. The *Sharpe* reflecting circle.
„ 19. The *Brisbane* circle.
„ 20. The *Baker* universal equatorial.
„ 21. The *Reade* transit.
„ 22. The *Matthew* equatorial, by Cooke.
„ 23. The *Matthew* transit instrument.
„ 24. The *South* transit instrument.
„ 25. A sextant, by Bird (formerly belonging to Captain Cook).
„ 26. A globe showing the precession of the equinoxes.
The *Sheepshanks* collection :—
„ 27. (1) 30-inch transit instrument, by Simms, with level and two iron stands.
„ 28. (2) 6-inch transit theodolite, with circles divided on silver; reading microscopes, both for altitude and azimuth; cross and siding levels; magnetic needle; plumb-line; portable clamping foot and tripod stand.
„ 29. (3) Equatorial stand and clock movement for $4\frac{6}{10}$-inch telescope (telescope lost); double-image micrometer; two wire micrometers; object-glass micrometer.
„ 30. (4) $3\frac{1}{4}$-inch achromatic telescope, with equatorial stand; double-image micrometer; one terrestrial and three astronomical eyepieces.

No. 31. (5) $2\frac{3}{4}$-inch achromatic telescope of $28\frac{1}{4}$-inch focal length, with stand; one terrestrial and three astronomical eyepieces.

„ 33. (7) 2-foot navy telescope.

„ 34. (8) Transit instrument of 45 inches focal length, with iron stand and also Y's for fixing to stone piers; two axis levels.

„ 35. (9) Repeating theodolite, by Ertel, with folding tripod stand.

„ 36. (10) 8-inch pillar sextant, by Troughton, divided on platinum, with counterpoise stand and artificial horizon.

„ 37. (11) Portable zenith telescope and stand, $2\frac{3}{4}$-inch aperture and 45 inches focal length; 10-inch horizontal circle and 8-inch vertical circle, reading to 10″ by two verniers to each circle.

„ 38. (12) 18-inch Borda repeating circle, by Troughton, $2\frac{1}{8}$-inch aperture and 24 inches focal length; the circles divided on silver, the horizontal circle being read by four verniers, and the vertical circle by three verniers, each to 10″.

„ 39. (13) 8-inch vertical repeating circle, with diagonal telescope, by Troughton and Simms; circle divided on silver, reading to 10″; a 5-inch circle at eye end, reading to single minutes; horizontal circle 9 inches diameter in brass to single minutes.

„ 40. (14) A set of surveying instruments, consisting of a 12-inch theodolite for horizontal angles only, reading to 10″; two sets of adjusting plates; tripod stand with enclosed telescope; heavy stand for theodolite; Y-piece of level; two large and three small ground-glass bubbles divided; level collimator, object-glass $1\frac{5}{8}$-inch diameter and 16 inches focal length; micrometer eyepiece, comb, and wires; mercury bottle and trough.

„ 41. (15) Level collimator, with object-glass $1\frac{7}{8}$-inch diameter and 16 inches focal length; stand, rider-level, and fittings.

„ 42. (16) 10-inch reflecting circle by Troughton, reading by three verniers to 20″; counterpoise stand; artificial horizon, with mercury; two tripod stands.

„ 43. (17) Hassler's reflecting circle, by Troughton, with counterpoise stand.

„ 44. (18) 6-inch reflecting and repeating circle, by Troughton and Simms, contained in three boxes, two of which form stands. Circle divided on silver, reading to single minutes; two inside arcs divided to single degrees, 150 degrees on each side; artificial horizon and mercury.

„ 45. (19) 5-inch reflecting and repeating circle, by Lenoir, of Paris.

No. 46. (20) Reflecting circle, by Jecker, of Paris, 11 inches in diameter, with one vernier reading to 15″.
„ 47. (21) Box sextant ; reflecting plane and level.
„ 48. (22) Prismatic compass, by Troughton and Simms.
„ 49. (23) Mountain barometer.
„ 50. (24) Prismatic compass, by Thomas Jones, mounted with a cylindrical lens.
„ 51. (25) Ordinary $4\frac{1}{2}$-inch compass with needle.
„ 52. (26) Dipping needle, by Robinson.
„ 53. (27) Compass needle, mounted for variation.
„ 54. (28) Magnetic intensity needle, by Meyerstein, of Göttingen ; a strongly fitted brass box with heavy magnet ; filar suspension.
„ 55. (29) Box of magnetic apparatus.
„ 56. (30) Hassler's reflecting circle, by Troughton ; a $10\frac{1}{2}$-inch reflecting and repeating circle, with stand and counterpoise, divided on platinum with two movable and two fixed indices ; four verniers reading to 10″.
„ 57. (31) Box sextant and glass plane artificial horizon, by Troughton and Simms.
„ 58. (32) Plane $2\frac{3}{8}$-inch speculum, artificial horizon and stand.
„ 59. (33) $2\frac{1}{2}$-inch circular level horizon, by Dollond.
„ 60. (34) Artificial horizon, roof, and trough ; the trough $8\frac{1}{4}$ by $4\frac{1}{2}$ inches ; tripod stand.
„ 61. (35) Set of drawing instruments, consisting of 6-inch circular protractor and common protractor, T-square ; one beam compass.
„ 62. (36) A pantograph.
„ 63. (37) A noddy.
„ 64. (38) A small Galilean telescope with object-glass of rock crystal.
„ 65. (39) Five levels.
„ 66. (40) 18-inch celestial globe.
„ 67. (41) Varley stand for telescope.
„ 69. (43) Telescope, with object-glass of rock crystal.
„ 71. Portable altazimuth tripod.
„ 72. Four polarimeters.
„ 74. Registering spectroscope, with one large prism.
„ 76. Two five-prism direct-vision spectroscopes.
„ 78. $9\frac{1}{4}$-inch silvered-glass reflector and stand, by Browning.
„ 79. Spectroscope.
„ 80. A small box, containing three square-headed Nicol's prisms ; two Babinet's compensators ; two double-image prisms ; three Savarts ; one positive eyepiece, with Nicol's prism ; one dark wedge.
„ 81. A back-staff, or Davis' quadrant.
„ 82. A nocturnal or star dial.
„ 83. An early non-achromatic telescope, of about 3 feet focal length, in oak tube, by Samuel Scatliffe, London.

No. 84. A Hollis observing chair.
„ 85. Double-image micrometer, by Troughton and Simms.
„ 86. $4\frac{1}{2}$-inch Gregorian reflecting telescope, by Short, with altazimuth stand and 6-inch altitude and azimuth circles and two eyepieces.
„ 87. $3\frac{1}{4}$-inch Gregorian reflecting telescope with wooden tripod stand.
„ 88. Pendulum, with 5-foot brass suspension rod, working on knife-edges, by Thomas Jones.
„ 89. A Rhabdological Abacus. A contrivance invented by Mr. H. Goodwyn, consisting of a box filled with compartments, in which are square rods covered with numbers, which can be arranged so as to facilitate the labour of multiplying high numbers.
„ 90. An Arabic celestial globe of bronze, $5\frac{3}{4}$ inches in diameter.
„ 91. Astronomical time watch-case, by Professor Chevallier.
„ 92. 2-foot protractor, with two movable arms, and vernier.
„ 93. Beam compass, in box.
„ 94. 2-foot navigation scale.
„ 95. Stand for testing measures of length.
„ 96. Artificial planet and star, for testing the measurement of a fixed distance at different position angles.
„ 97. 12-cell Leclanché battery.
„ 98. 2-foot 6-inch navy telescope, with object-glass $2\frac{1}{2}$ inches, by Cooke, with portable wooden tripod stand.
„ 99. 12-inch transit instrument, by Fayrer and Son, with level and portable stand.
„ 100. 9-inch transit instrument, with level and iron stand.
„ 101. Small equatorial sight instrument, by G. Adams, London.
„ 102. Sun-dial, by Troughton.
„ 103. Sun-dial, by Casella.
„ 104. Sun-dial.
„ 105. Box sextant, by Troughton and Simms.
„ 106. Prismatic compass, by Schmalcalder, London.
„ 107. Compass, by C. Earle, Melbourne.
„ 108. Prismatic compass, by Negretti and Zambra.
„ 109. Dipleidoscope, by E. Dent.
„ 110. Abney level, by Elliott.
„ 111. Pocket spectroscope, by Browning.
„ 112. Universal sun-dial.
„ 113. Double sextant, by Jones.
„ 114. Two models, illustrating the effects of circular motions.
„ 115. A cometarium.
„ 117. Two old sun-dials.
„ 118. A $10\frac{1}{2}$-inch sixteenth-century celestial globe, on bronze tripod stand.
„ 119. Specimens of diffraction gratings, by Prof. W. A. Rogers.
„ 120. A 6-prism spectroscope, by Browning.

No. 121. Spitta's improved maximum and minimum thermometer.
„ 122. A 6-inch speculum, with flat; the speculum said to be by Sir W. Herschel, and re-figured by Sir J. Herschel.
„ 123. A 6-inch refracting telescope, by Grubb, with 3 eyepieces.
„ 124. Position micrometer, by Cooke.
„ 125. A 6-inch refracting telescope, by Simms, with eyepieces and solar diagonal.
„ 126. $3\frac{1}{2}$-inch portable refracting telescope, by Tulley, with tripod stand.
„ 127. Globe representing the visible surface of the Moon, by John Russell, R.A. (1797).
„ 128. Bichromate battery and Ruhmkorff coil.
„ 129. Slater's improved armillary sphere.
„ 130. 10-inch brass pillar sextant with counterpoise stand, by Troughton.
„ 131. Double box sextant, by Cary.
„ 132. Equatorially mounted camera with $2\frac{1}{2}$-inch portrait lens and telephotographic enlarging lens by Dallmeyer; iron pillar.
„ 133. $3\frac{1}{4}$-inch equatorial by Ross, with tall tripod stand, equatorial mounting, eyepieces, and micrometer.
„ 134. Old transit instrument, 2-inch aperture and 3 feet focal length (without stand), formerly belonging to Dr. Longfield, of Cork.
„ 135. Globe of Mars, by E. M. Antoniadi.
„ 136. A small universal instrument by W. and S. Jones, London; the telescope $1\frac{1}{2}$-inch aperture and 15 inches focal length. [Presented by Miss Moore.]
„ 137. Polar siderostat by Hilger, with $4\frac{1}{8}$-inch mirrors. [Presented by Mr. Alexr. Foote.]
„ 138. Transit instrument, aperture $2\frac{3}{4}$-inch, with collimator and stand. [Presented by Mrs. Cross.]
„ 139. Transit instrument, aperture $1\frac{1}{2}$-inch, with portable stand. [Presented by Mrs. Cross.]
„ 140. $3\frac{1}{2}$-inch object-glass and tube. [Presented by Mrs. Cross.]
„ 141. 9-inch Newtonian reflector and equatorial stand. [Presented by Mrs. Cross.]

Besides the above, there is the following apparatus available for eclipse work:—

4 Slits for spectroscope.
Abney doublet lens used in photographing the corona.
2 Dallmeyer negative enlarging lenses.
Cœlostat with 16-inch plane mirror.

The following instruments are lent, during the pleasure of the Council, to the undermentioned persons :—

No. 22. The *Matthew* equatorial, to Mr. C. Thwaites.
„ 23. The *Matthew* transit, to Captain W. Noble.
„ 28. (2) 6-inch theodolite and stand, to Dr. A. A. Common.
„ 29. (3) Equatorial mounting, clock, &c., to the Rev. C. D. P. Davies.
„ „ Wire micrometer (No. 2), to the Rev. C. D. P. Davies.
„ 30. (4) $3\frac{1}{4}$-inch equatorial and stand, to Mr. M. E. J. Gheury.
„ „ Double-image micrometer, to the Rev. W. J. B. Roome.
„ 31. (5) $2\frac{3}{4}$-inch telescope (object-glass only), to the Rev. C. D. P. Davies.
„ 37. (11) Zenith telescope (object-glass only), to the Rev. C. D. P. Davies.
„ 57. (31) Box sextant, to Dr. A. A. Common.
„ 69. (43) Telescope with rock-crystal object-glass, to Sir W. Huggins.
„ 98. 2-foot 6-inch navy telescope, to the Rev. J. M. Bacon.
„ 123. 6-inch telescope, by Grubb (object-glass only), to Mr. W. E. Wilson.
„ 125. 6-inch refractor, by Simms, to Dr. A. A. Common.
„ 126. $3\frac{1}{2}$-inch portable telescope by Tulley, to Mr. J. H. Bell.
„ 130. 10-inch pillar sextant, to Mr. F. Robbins.
„ 133. $3\frac{1}{4}$-inch equatorial, by Ross, to Dr. A. W. Roberts.
„ 139. Transit instrument and stand, to the Rev. C. L. Tweedale.
„ 140. $3\frac{1}{2}$-inch object-glass and tube, to the Rev. C. L. Tweedale.

Award of the Gold Medal.

The Council have awarded the Society's Gold Medal to Professor Hermann Struve for his work on the satellites of *Saturn*. The President will lay before the Society the grounds upon which the award has been founded.

Publications of the Society.

During the past year vol. lxii. of the *Monthly Notices* has been issued.

In accordance with the arrangement made with the Royal Society, mentioned in last year's Annual Report, two Appendices to vol. lxii. were issued, containing the preliminary reports on the Observations of the Total Solar Eclipse of 1901 May 18, and other papers.

Appendix III. to vol. liv. of the *Memoirs* has also been published, containing Sir Norman Lockyer's account of the observations of the total Solar Eclipse of 1900 May 28, made at Santa Pola, Spain.

It is hoped that vol. liv. of the *Memoirs* will appear in the course of the present year.

Obituary.

The Council regret that they have to record the loss by death of the following Fellows and Associates during the past year :—

Fellows :—* J. J. Aubertin.
† John Brett.
Rev. S. B. Burnaby.
Col. E. H. Cooper.
P. F. Duke.
‡ Commander E. J. Griffin.
Arthur Kennedy.
A. O. Hilger.
G. D. Lardner.
Rev. Thomas Wiltshire.
Associates :—Marie Alfred Cornu.
Hervé Faye.

John James Aubertin was born in 1818, being the fourth son of the Rev. Peter Aubertin, Rector of Chipstead, Surrey. Much of his life was spent in travel, and he published several works on his experiences in Mexico, South Africa, &c. He observed the total solar eclipse of 1870 at Gibraltar, and in 1893 made the journey to Chile to observe the eclipse on the 16th of April of that year. He joined Professor Schaeberle's party at Mina Bronces, and after observing the eclipse travelled through Peru, visiting the Arequipa Observatory. He wrote a popular account of his travels and observations, entitled *By Order of the Sun*.

Mr. Aubertin was a Spanish and Portuguese scholar, and published a translation of the great Portuguese epic of Camoens, the *Lusiad*, and seventy of his sonnets.

He was elected a Fellow of the Society on the 11th of January 1895, and died at Weymouth on the 24th of August 1900.

Sherrard Beaumont Burnaby was born at Doctors' Commons, London, on the 2nd of November 1831. His father died when the son was a boy, and the latter was placed under the

* Died in 1900, but death not reported till 1902.
† Obituary given in last Annual Report.
‡ Died in 1901, but death not reported till 1902.

guardianship of the Vicar-General, Dr. S. B. Burnaby. Mr. Burnaby was educated at St. Paul's School, from which he passed to Christ's College, Cambridge, where he was a contemporary of Sir Walter Besant. He was ordained deacon in 1857 and priest in 1859 ; and from 1857 to 1864 was curate of Holy Trinity, Stepney. His health having broken down he left Stepney, and was for a time chaplain to Earl Fortescue. In 1866 he was appointed Rector of Wapping, and while there took the chief part in arranging hospital accommodation, &c., during an epidemic of cholera, subsequently becoming a sufferer himself. In 1871 Mr. Burnaby married, and in 1873 was appointed Vicar of Hampstead, where he remained till 1900, when he was compelled to resign his living, much to the regret of his parishioners, owing to a serious affection of the vocal chords. In November 1899 he had undergone a serious operation from which he never really recovered.

Mr. Burnaby was greatly interested in questions concerning chronology and the calendar, and had in hand a comprehensive work on various calendars and eras. Less than a year before his death he published a treatise on the Jewish and Muhammadan Calendars, dealing very fully with the intricacies of the subject, simplifying and correcting the rules for both calendars, giving explanations for the rules and Chronological Tables.

He was elected a Fellow of the Society on the 9th of April 1897 ; he died at Great Missenden, Bucks, on the 23rd of February 1902, leaving three sons living.

The Right Honourable Edward H. Cooper was born in 1827 in Westmeath, and died at 42 Portman Square, London, on the 26th of February 1902. He entered the army and held commissions successively in the 7th Hussars, 72nd Seaforth Highlanders, and the Grenadier Guards. He retired in 1865, and for the years 1867–69 represented Sligo in the House of Commons. From 1877 Colonel Cooper was Lieutenant and Custos Rotulorum for County Sligo. He was made Privy Councillor for Ireland in 1899. Colonel Cooper succeeded to Markree Castle at the death of his uncle, Mr. E. J. Cooper, in 1872. Mr. Cooper had established there what was at its erection one of the finest private observatories, with an excellent transit circle, and the largest refractor in the world with the exception of those at Pulkowa and Washington. With his assistant, Mr. Graham, he made many observations of minor planets, and very extensive observations of zodiacal stars. Colonel Cooper had not his uncle's interest in astronomy, but was interested in meteorology. He had meteorological observations regularly made and reported, and Markree was one of the best meteorological stations in Ireland. In 1876 Colonel Cooper appointed in charge of the observatory Dr. Doberck, who made observations of double stars. Reports of the observatory were given each year from 1876–1883. In 1883 Mr. Marth succeeded Dr. Doberck. He

carried out the meteorological observations, but made no astronomical ones, devoting his spare time to the construction of ephemerides for physical observation of the Moon and planets. Mr. Henkel was appointed as Marth's successor in 1898, and remained in charge of the observatory till Colonel Cooper's death. Colonel Cooper married in 1858 Charlotte Maria Mills, and had several children, the eldest of whom died in South Africa in 1900.

Colonel Cooper was elected a Fellow of the Society in 1872.

Edward John Griffin was born in Dublin on the 19th of September 1848, and was educated at the Merchant Taylors' School. He entered the Mercantile Marine, and served as junior officer in the transport *Kingston* during the Abyssinian war in 1868–9. In January 1878 he joined the Union Steam Ship Company, and in 1879 was given the command of the *Danube* of that line. In 1884 he commanded the *Anglian*, which conveyed the troops to Egypt, and in 1885 of the *Arab*, which was the head-quarter ship of the transport staff at Suakim. For his services ashore and afloat he was awarded the "Egyptian Medal," the "Khedive's Bronze Star," and the "Suakim 1885 Clasp." At the conclusion of the war he conveyed the Australian Contingent back to Sydney, and received from the Government of New South Wales appreciative recognition for his services.

In 1887 he was elected a Younger Brother of the Trinity House. He reached the rank of commander in the Royal Naval Reserve in 1896. In 1898 he was placed in command of the R.M.S. *Briton*, the largest vessel of the Union Steam Ship fleet, and remained in her until his death on the 7th of July 1901.

Commander Griffin married at the Cape in 1878, and leaves a widow and six children.

He was elected a Fellow of the Society on the 14th of January 1898.

Arthur Kennedy was born at Balham in 1852, and was the son of Mr. Thomas Kennedy, of Balham and Chancery Lane, solicitor. He was sent to school at Brighton, and later to the Lycée at Orleans. At the age of sixteen he was articled to his father, becoming in 1874 a partner in the firm of Kennedy, Hughes, and Kennedy, and eventually senior partner.

Mr. Kennedy did no original work in astronomy, but throughout his life had a keen interest in astronomical studies. He devoted much of his leisure time to observing, and delighted his friends at Epsom by astronomical lectures in his own house. He was elected a Fellow of the Society on the 13th of March 1891, and was a constant attendant at the meetings. He joined the British Astronomical Association soon afterwards, and served on its Council from 1896 to 1901, and took a constant and deep interest in the welfare and progress of that Society.

Mr. Kennedy married in 1887, and leaves three daughters.

His death took place under exceptionally sad circumstances, as he was accidentally drowned at Bacton-on-Sea on the 14th of August 1902. He will be remembered by a large circle of friends, who admired his professional ability and appreciated his kindly and unselfish character.

Otto Hilger was born in Darmstadt on the 20th of January 1850, and when quite a young boy was apprenticed to his father, who was Master of the Mint in that city. After finishing his apprenticeship he went to Frankfort and worked as a mechanical engineer with his elder brother Adam. In 1868 the two Hilgers went to Paris, where they started a workshop and obtained work for the Observatory. Being German subjects, they were obliged to leave Paris at the outbreak of the Franco-Prussian war. They came to London, and Adam Hilger became foreman with Mr. John Browning, Otto being employed by the same firm. Five years later Adam Hilger commenced business on his own account as astronomical and optical instrument maker, and took his brother into his employment. In 1888 Otto Hilger was appointed by Lord Blythswood to take charge of his private laboratory, where, under Lord Blythswood's directions, he was engaged in constructing an engine for ruling gratings, when he was compelled, in 1897, on the death of his brother, to return to London and take charge of the business.

Mr. Hilger died on December 18. He leaves a widow and three children.

He was elected a Fellow of the Society on the 8th of February 1901.

George Darley Lardner, second son of the Rev. Dionysius Lardner, LL.D., D.C.L., F.R.S., by his first wife, Cecilia Flood, was born in Dublin on the 21st of August 1818. Dr. Dionysius Lardner probably did more than any other man in the first half of the nineteenth century to advance the cause of education. His high mathematical attainments, combined with the unusual lucidity and ability with which he explained applied mathematics and mechanics, gave him a power in education which has seldom been equalled in that branch of knowledge. But his genius was versatile ; all knowledge fascinated him, and, not content with writing many valuable works on various scientific subjects, he produced his celebrated *Cabinet Encyclopædia* in 133 volumes, in which he was assisted by the most prominent men of the time in literature and science.

So brief a reference to his distinguished father is due because George Darley inherited many of his gifts, but none of his ambitions. If he had not read very high mathematics, he had mastered sufficient to enable him to take great interest in astronomy, and was able to explain phenomena in clear and simple language. He had even a greater love than his father had for general literature. Possessing a good memory and a

knowledge of both French and German, he was a fund of information to his friends and the most charming companion, a good conversationalist, and no mean "raconteur." The most unassuming of men and lacking his father's ambition, his great abilities were reserved for his official duties and for those who knew him, or whom he could benefit by them.

Educated first at a school at Epsom, Surrey, he went to Paris, where he studied for the medical profession in the French University. While in Paris he was offered a commission in the Commissariat Department of the British army. Having no predilection for the medical profession, he readily accepted it, and was sent to the Cape of Good Hope, where he served on the frontier. From the Cape he went to New Zealand and took part in the first Maori war, receiving the medal. He married at Auckland, New Zealand, in 1841, and returned home some years later. He served in Ireland, and then for many years in the West Indies and Honduras, and, during his last appointment at Barbados in the sixties, was head of his department in the Windward and Leeward Islands. He again served in Ireland during the Fenian troubles of 1865 and 1866, and he retired on a pension after thirty years' service, in 1868. After his retirement from the army Commissary-General Lardner occupied his leisure in literary and scientific pursuits, and was never happier than when he was engaged in preparing for and delivering to juvenile audiences lectures on astronomy and physics. He compiled and printed for private circulation a text-book on elementary astronomy. Both mentally and physically he was in full activity when he was suddenly called away without illness on the 14th of January 1902, in his eighty-fourth year. He was elected a Fellow of the Society on the 8th of February 1895. By his first wife, Mary Macintosh, who died in 1870, he had two children, who both survive—William George Lardner, of Hove, Sussex, and Mary Ann, married to Colonel R. H. Vetch, C.B., R.E. His second wife, Emily D. Clarke, is also living.

[For the above particulars the Council is indebted to Colonel R. H. Vetch.]

The Rev. Thos. Wiltshire, M.A., D.Sc., &c., was born in London on the 21st of April 1826, and was through his mother a descendant of the ancient family of Pomeroy of Berry Pomeroy, in Devonshire. As he was a delicate child he was never sent to school, but educated by a tutor at home until he was of an age to attend King's College, whence in due course he proceeded to Trinity College, Cambridge, where in 1850 he graduated as Senior Optime. He was ordained deacon in the same year by the Bishop of Rochester, and subsequently priest by the Bishop of London in 1853. He held his first curacy at Riddings, in Derbyshire. Being prohibited by his medical attendant from living in a climate obviously unsuited to him, he came to London, and for

some years resided at Brompton. He then did occasional Sunday duty at various churches, and ultimately Dr. Kynaston, the Rector of St. Nicholas Cole Abbey, gave him the Rectory House (afterwards demolished in making Queen Victoria Street) on condition that he would look after the parish generally. Thus for some years he lived in the very heart of the City of London. Another civic appointment he obtained in the shape of the Evening Lectureship at St. Clement's, Eastcheap. This dies with him. From his youth he took a keen and abiding interest in geology, and joined the staff of King's College as Lecturer in Geology in 1872. In 1881 he was appointed Assistant Professor, and was Professor from 1890 to 1897. He sat for many years on the Council of the Geological Society, of which until quite recently he was Treasurer. He was for many years, too, Honorary Secretary to the Palæontographical and Ray Societies, the members of which united in 1890 in presenting him with his portrait and a testimonial. This portrait now hangs in the "Wiltshire" collection of fossils in the Woodwardian Museum at Cambridge, to which he was a benefactor, having presented his old University with his splendid collection of fossils, and founded a "Wiltshire" prize for proficiency in geology and mineralogy. In recognition of this the honorary degree of D.Sc. was conferred on him on April 27, 1899. He was a member of the Clothworkers' Company, and at one time Master, an office held by Samuel Pepys in the reign of Charles the Second, and by Lord Kelvin quite recently. In this connection he also founded prizes in the Company's Grammar School at Sutton Valence, in Kent. He was also on the Executive Committee of the City and Guilds of London Institute, and on the Council of the Yorkshire College, King's College, &c., and was a member of the Athenæum Club. His interest in astronomy was purely in its mathematical aspect, as at no time was he ever a practical observer. It is some years since he attended any of our meetings. On the night of the 26th of October last he went up to London from his residence at Blackheath, and preached his usual sermon as evening lecturer at St. Clement's, Eastcheap, returning apparently in perfect health, but early the next morning died in his sleep, without a struggle, from heart failure. He was elected a Fellow of this Society on the 9th of March 1860.

Marie Alfred Cornu was born on the 6th of March 1841 at Châteauneuf, near Orleans.

He was sent to the Lycée at Orleans, and in 1860 entered the École Polytechnique, and two years later the École des Mines. He finished his course here in 1866, and the next year, at the age of 26, he was chosen as Professor of Physics at the École Polytechnique.

His earliest researches, communicated to the Académie des Sciences in 1863–65, were on "The Reflection of Light at Metallic Surfaces" and kindred subjects. Soon after this he

commenced his researches on "The Velocity of Light," and devised various improvements on Fizeau's method, which he tested by observations between the École Polytechnique and Mont Valérien, stations about $6\frac{1}{2}$ miles apart. The desirability of a redetermination of the velocity of light with all attainable accuracy was brought into prominence by its relation to the solar parallax, which was then occupying the thoughts of astronomers in connection with the approaching transits of *Venus*. Early in 1874, at the suggestion of Le Verrier and Fizeau, the Council of the Observatory of Paris asked Cornu to make this redetermination.

He chose the terrace of the Observatory as one station, and erected on it a telescope of 15 inches aperture and 30 feet focus to transmit a beam of light to a mirror mounted on the tower of Montlhéry, about 14 miles distant, which reflected the light back to him. The toothed wheel by which he measured the time of transmission to Montlhéry and back was capable of 1600 revolutions per minute, and he was able with this apparatus to obtain a movement of as many as twenty-one teeth of the wheel during the passage and repassage of the beam of light. As a mean of many experiments he found for the velocity of light *in vacuo* 186,700 miles per second, which it may be interesting to note gives, in combination with the value 20″·52 for the constant of aberration, a value of 8″·77 for the solar parallax. An interesting account of Cornu's method and results is given in *Nature*, 4th of February 1875.

In conjunction with M. Baille, Cornu, between 1870 and 1880, made several determinations of the mean density of the Earth. They used the method of the torsion balance designed by Michell, and first employed by Cavendish, commencing their work by careful subsidiary studies of the torsion balance. Their apparatus, which was set up in a cellar of the École Polytechnique, differed from that used by their predecessors in several particulars, especially in the employment of much smaller attracting masses, and in the use of hollow spheres filled with mercury, which could be pumped from a sphere on one side to another on the other side, thus avoiding the disturbance caused by the movement of heavy solid masses. In July and August 1872 they obtained the result 5·56, and later in the year 5·50, the former result being considered the better. In 1878 they again obtained the result 5·56, and, as showing the stability of the apparatus, they state that the time of swing of the balance did not vary from 408 seconds by more than one or two tenths for over a year. The most recent value—that found by Mr. C. V. Boys in 1894 by the employment of quartz fibres—is 5·527.

It is only possible to give a brief summary of Cornu's many important spectroscopic researches. In 1878 and 1879 he contributed papers to the Académie des Sciences and to the Royal Society, dealing with the effect of atmospheric absorption on the ultra-violet end of the spectrum. He showed that, from this

cause, it was impossible to obtain the solar spectrum beyond a definite limit, which he fixed at λ 2930. He also gave a formula for the limit as dependent on the altitude of the Sun and the elevation of the observer above sea-level, and proved that the absorption was caused by the oxygen and nitrogen of the atmosphere and not by the aqueous vapour or dust. He confirmed his formula experimentally by showing that a triple line of aluminium at λ 1860 was extinguished by four metres of air.

About the year 1886 Cornu made a series of observations and measures of wave-length of the atmospheric and solar lines which occur in the bands called a, B and A by Ångström and near D. His method of discriminating between solar and telluric lines consisted in throwing on the slit of his spectroscope an image of the two limbs of the Sun in rapid succession. The solar lines are thus displaced alternately to the violet and red, owing to the Sun's rotation, while the atmospheric lines remain stationary.

In 1886, the year after Balmer gave his well-known formula for the wave-lengths of the hydrogen lines, Cornu made careful determinations of their wave-lengths, the ultra-violet hydrogen lines up to that time being only known in the stellar spectra of Huggins and Vogel. In 1885 he concluded, from observations of the spectra of aluminium and thallium, that in metallic spectra there are series of lines which obey a law like that of the hydrogen lines, and that the lines which thus fall into series are the lines which most readily admit of reversal. The later work of Kayser and Runge in the determination of series is well known.

Cornu published maps of the ultra-violet part of the solar spectrum in continuation of Ångström's work. These are extremely accurate, but are not accompanied by tables, and at the present time Rowland's tables are more generally useful. He also investigated the ultra-violet part of many metallic spectra.

When *Nova Cygni* was discovered in 1876 Cornu was the first to investigate its spectrum. As he used a somewhat high dispersion he obtained the emission spectrum only. He measured the wave-lengths of eight bright lines, six of which he identified as C, D_3, *b*, F, Hγ, and the corona line.

On the occasion of the transit of *Venus* in 1874 and later, at the request of the Council of the Observatory of Paris, he considered in what way object glasses made for visual observation could be used photographically. Reverting to an idea of Sir John Herschel's, he showed that the separation of the lenses by a distance rarely more than $1\frac{1}{2}$ per cent. of the focal distance transformed an achromatism adapted for visual rays to one adapted for the photographic rays. He applied his method to obtain photographs of the Moon with the large object glass of the Paris Observatory, and obtained excellent results. It is of interest to note that he profited by the transparency of the

collodion film to guide on a point on the surface of the Moon, and by guiding on it to allow for the motion of the Moon.

When the photographic chart of the sky was begun Cornu was one of the delegates appointed by the Académie des Sciences, and he was an active member of the various astrographic congresses.

The memoirs which Cornu contributed to the Académie des Sciences are models of clear exposition. His lectures and addresses were equally marked for their lucidity and admirable style. In England he lectured on several occasions at the Royal Institution, and in 1899 he gave the Rede lecture at Cambridge on the wave theory of light.

The importance of his scientific work was appreciated both in France and in foreign countries. In 1878 he received the Lacaze prize of the Académie des Sciences and the Rumford Medal of the Royal Society. In 1896 he was President of the Académie des Sciences. In 1886 he was appointed to the Bureau des Longitudes. In England he was elected a foreign member of the Royal Society in 1884; the degree of Hon. Sc. D. was conferred on him at Cambridge in 1899. He was elected an Associate of the Royal Astronomical Society in 1890.

M. Cornu continued to discharge his duties at the École Polytechnique, and was engaged in his usual scientific work till Easter. He left Paris soon afterwards, apparently in the best of health, to spend a short vacation at Orleans. He died on the 12th of April, after a very short illness.

M. Cornu had many friends in England as well as in France, who will feel that his death is a personal no less than a scientific loss.

Hervé Faye was born on the 1st of October 1814. He entered the École Polytechnique in 1832, and in 1836 became an assistant at the Paris Observatory. In 1844 he received the Lalande Prize of the Academy for his discovery of a comet and his subsequent researches on it. In 1847 he became a Member of the Institute, and was shortly afterwards appointed lecturer on Geodesy at the École Polytechnique. In 1854 he became Rector of the Academy and Professor of Astronomy at Nancy. In 1862 he succeeded Biot at the Bureau des Longitudes. In 1870 he was chosen as Inspector-General of Secondary Scientific Education, and in 1874 returned to the École Polytechnique as Professor of Astronomy and Geodesy. He was for a time Minister of Public Instruction.

From 1878–1888 he was Inspector-General of Higher Education.

Faye's discovery of the comet which bears his name was made on the 22nd of November 1843, and communicated to the Academy of Sciences. It was followed on the 6th of December by a communication of the elements of the parabolic orbit obtained from observations made on the 24th and 29th of

November and the 2nd of December. He soon found that the comet was moving in an elliptic orbit, and proceeded to calculate one by the methods given by Gauss in the *Theoria Motus*. He was anticipated in this by Goldschmidt, but it is of interest to observe that this was the first comet for which an elliptic orbit was computed from observations extending over a comparatively short period. From observations extending over 48 days Faye found a period of 7·2 years and an eccentricity of about one-half.

His interest in comets led him to compute an elliptic orbit for D'Arrest's Comet in 1844, and for De Vico's Comet, which Faye also discovered independently, in the following year. Of the 302 papers which appear under his name in the Royal Society *Catalogue* as being written between 1843 and 1883 a considerable number relate to comets, especially to the forms of the tails and to the evidence which can be deduced as to the existence of a resisting medium. In the former connection he studied Donati's Comet and in the latter that of Encke. He considered that the phenomena of comets' tails were to be accounted for by a repulsive force due to the Sun's heat.

A number of Faye's earlier memoirs relate to the details of meridian observations, such as the division errors of the Circle of Gambey and the discordances found between direct observations of zenith distance and those made by reflexion from mercury. He has several papers on absolute declinations and the systematic errors of the earlier catalogues of last century.

Faye was attracted by the problems of solar physics. It cannot be said that he made observations like those of Carrington or the spectroscopic discoveries which have enriched this field of astronomical research during the last half-century, but it was to him we owe the first exposition of a theory of the Sun's constitution which is in its general outlines accepted at the present time.

Herschel's theory of the Sun as a cool, dark, habitable globe was generally held till the middle of last century, and Miss Clerke in her *History of Astronomy* gives a reference to a treatise upholding this view as late as 1866. Faye, in January 1865, communicated to the Academy of Sciences a memoir in which he advanced the view that the Sun is to be regarded as a heat-engine, designed to radiate heat from its surface. "Le foyer est la masse même de l'astre, dotée, dès l'origine, d'une prodigieuse quantité de calorique que la contraction progressive de la masse entière contribue à alimenter. La source de froid est l'espace céleste. Le condensateur, c'est la photosphère. Le moyen de régularisation, c'est l'invariabilité naturelle de la température à laquelle se produisent les combinaisons chimiques, et de celle où elles se détruisent. Le jeu de la machine consiste en courants ascendants et descendants, les uns charriant des vapeurs, les autres des substances solides et refroidies. Le moyen de transport de la chaleur, du centre à la superficie, consiste en ce que ces substances solides ou oxydées emprun-

tent aux couches centrales, pour se dissocier, une quantité que leurs vapeurs reportent plus haut, dans la photosphère, ou reproduisent en se combinant." *

Faye is perhaps best known for his daring attempt to supersede Laplace's explanation of the formation of the planetary system. His views are expounded in the *Comptes Rendus*, vol. xc., in the *Annuaire pour l'An* 1885, *Bureau des Longitudes*, and in his essay *Sur l'Origine du Monde*. An account of Faye's theory and a critical estimate of its value is given by Professor G. H. Darwin in *Nature* for the 2nd of April 1885. Faye contended that if Laplace's nebular hypothesis were correct the satellites, not only of *Uranus* and *Neptune*, but of all the planets would have a retrograde motion. He met this difficulty by assuming evolution from meteorites rather than nebulous matter, and by the aggregation of the inner planets in the midst of these meteorites before their masses were mainly condensed in a central Sun.

"On the whole," Professor Darwin concludes, "we must hold the opinion that there are great difficulties in the acceptance of M. Faye's theory, notwithstanding its excellences. The time does not appear yet ripe for definite judgment on this very complex subject, but science is undoubtedly the gainer by such suggestive theories. Whilst a false statement of fact always proves a serious detriment, the enunciation of false or partially true theories is always the incentive to, or initiation of, the discovery of truth."

In addition to many Academic distinctions Faye received the Grand Cross of the Legion of Honour, in recognition of his numerous services to the Government. His scientific labours were acknowledged and appreciated by learned societies in Europe and America, who enrolled him among their members. He has been an Associate of our Society since 1848, and it is of interest to note that he was elected on the same day as Professor Galle of Berlin and Dr. Otto Struve. These names carry us back a long way in the history of Astronomy, our next oldest Associates being Dr. Arthur Auwers and Dr. Wilhelm Förster, who were elected in 1866, eighteen years later.

M. Faye died on the 4th of July, at the age of 87, his death being followed a few months later by that of Madame Faye.

* *L'Origine du Monde*, p. 237.

Proceedings of Observatories.

The following reports of the proceedings of Observatories during the past year have been received from the Directors of the several Observatories, who are alone responsible for the same.

Royal Observatory, Greenwich.

Transit Circle.—During the year 1902 10,232 observations of transits and 8624 of zenith distances have been obtained. The progress made in the observations of the 10,000 stars within 26° of the pole, which will be used as reference stars for the astrographic photographs, is satisfactory, about 30,000 observations, or 60 per cent. of the total number required, having been made. The most troublesome observations, those of the 1400 stars within 10° of the pole, have all been made, with the exception of about 50. The observation of fundamental stars was also carried on continuously, a minimum of three determinations of right ascension and two of declination being obtained during the year for each star in the Greenwich clock star list. The Sun has been observed 159 times with the transit circle, its horizontal diameter 119 times, and its vertical diameter 145 times. The Moon has been observed 97 times in R.A. and N.P.D.; the mean error in R.A. of Hansen's Lunar Tables with Newcomb's corrections is $-0^s\cdot161$. The errors since 1883, when Newcomb's corrections were introduced into the *Nautical Almanac*, are as follows:—1883–1893, $+0^s\cdot043$; 1894–1896, $-0^s\cdot057$; 1897–1901, $-0^s\cdot137$; 1902, $-0^s\cdot161$.

The R − D discordance agrees with the values found in the last three years, the correction to the D observation being—

$+0''\cdot08 + 0''\cdot22$ sin Z.D. in 1899,
$+0''\cdot09 + 0''\cdot32$ sin Z.D. in 1900,
$+0''\cdot06 + 0''\cdot44$ sin Z.D. in 1901.
$+0''\cdot05 + 0''\cdot26$ sin Z.D. in 1902.

The re-reduction of Groombridge's observations has been pushed on energetically. The daily results are all finished, so as to exhibit mean R.A. and N.P.D. for the year of observation. The precessions are not yet computed, nor the reduction to $1810\cdot0$,

but these are in progress, and at the same time examination of all discordant results is being made.

The Altazimuth.—This instrument has been used as a reversible transit instrument in all four positions. During the year 1458 observations of right ascension and 1127 of north polar distance of the Sun, Moon, planets, and stars have been made. The nadir has been observed 411 times; 99 reflexion and direct observations of stars have been made, and 10 determinations of flexure on the collimators. The Moon has been observed 31 times on the meridian. Out of the meridian 240 azimuths and zenith distances of stars, 31 of the Moon, and 3 of *Venus* have been obtained. The observations for 1899 and 1900 are printed and will appear in the Greenwich volume for 1900.

The Reflex Zenith Tube.—Observations with this instrument, which were discontinued for a few years, have been resumed, as Mr. Chandler has shown (*Astron. Journ.* No. 511) that the anomalous results previously obtained are explained by the variation of latitude. By modifying the illumination somewhat it has been found that stars down to $6^{m}\cdot5$ can be observed, and by mounting the eyepiece on a slide good definition at a distance of nearly 1° from the zenith (centre of the field) has been secured. Additional wires have been inserted, in order that observations may be extended to stars as far as this distance from the zenith. Since May 27, when this was done, 111 double observations and 21 single observations of stars have been made. The stars observed most frequently are :

	Number of Double Obs.		Number of Double Obs.
β Drac.	9	π' Cygni	9
30 „	6	β Lacertæ	13
γ „	22	9 „	15
ι^{2} Cygni	5	Gr. 3087	5

Observations have also been made to determine the intervals of the wires and the mean value and errors of the screw.

Equatorials.—Occultations of 17 stars by the Moon have been observed by one or more observers during the year. The results are printed in *Monthly Notices*, vol. lxiii. 3.

28-inch Refractor.—The weather throughout the year has been unfavourable for double-star observations, but the programme of constantly observing all close and rapid binaries and of the difficult stars for which a large telescope is required has been carried out as far as possible. The stars measured during the year are :

106 pairs under $0''\cdot5$ apart,
86 „ between $0''\cdot5$ and $1''\cdot0$,
89 „ „ $1''\cdot0$ and $2''\cdot0$,
and 78 „ more than $2''\cdot0$ apart

On the average the stars whose distance apart is less than 1″·0 were measured on $2\frac{1}{2}$ nights, and those whose distance apart is greater than 1″·0 on 2 nights.

The following list gives some of the most interesting stars measured during the year :

Star.	Mags. m m	Dist. ″	Star.	Mags. m m	Dist. ″
ϵ Hydræ	3·5 , 6·0	0·1	42 Comæ	5·5 , 5·9	0·4
β 1266	7·2 , 7·5	0·2	γ^2 Androm.	5·0 , 6·2	0·4
β 524	6·0 , 7·0	0·2	β 733	6·0 , 11·0	0·7
β 525	7·0 , 7·0	0·2	β 603	6·4 , 10·2	0·8
Σ 2367	7·0 , 7·5	0·2	β 1081	4·5 , 14·0	5·2
ζ Bootis	3·5 , 3·9	0·2	β 1082	6·0 , 9·6	1·2
β 612	6·4 , 6·5	0·2	Procyon	1 , 14	5·3
β 614	6·0 , 9·5	1·0			

In addition good series of observations have been obtained of—

Star.	Mags. m m	Dist. ″	Star.	Mags. m m	Dist. ″
κ Pegasi	3·9 , 5·0	0·1	ζ Herculis	3·0 , 6·5	1·1
δ Equulei	4·5 , 5·0	0·1	70 Ophiuchi	4·1 , 6·1	1·6

A few observations of *Capella* have also been obtained.

Thompson Equatorial.—With the 26-inch refractor 61 photographs of *Neptune* and its satellite were obtained, of which 51 were measured. The results were communicated to the Society. At the present opposition 15 photographs were obtained before the end of December. Eighteen photographs of *Eros* were taken, either with the 30-inch reflector or 26-inch refractor, but only 5 of these are sufficiently good to measure. Comet *b* 1902 was photographed 4 times with the 26-inch, of which only one was measured, and 43 times with the reflector, of which 28 were measured. With an hour's exposure a very satisfactory photograph of the comet was obtained, showing the character of the tail. This was reproduced in *Monthly Notices*. Three successful photographs of Comet *d* 1902 were also obtained.

With the spectroscope 43 photographs of the spectra of some of the brighter stars have been obtained.

Astrographic Equatorial.—During the year 237 plates have been taken on 62 nights. Of these 25 taken for the Astrographic Chart or Catalogue have been rejected—viz. 14 because the exposure was interrupted by cloud or the plate did not come up to the standard in showing faint stars, 5 owing to errors of setting or guiding, and 6 for other defects. Of the remaining 212 plates 64 were of Nova *Persei*, 4 of the field surrounding

Eros, on which, however, the planet was not shown, 73 for the Astrographic Chart, 48 for the catalogue, 12 for the adjustments of the instrument, and 11 of Comet *b* 1902, of which, however, only one showed the comet sufficiently distinctly for good measures to be made.

Fourteen photographs of the pole have been taken with the Abney and Dallmeyer lenses of 33 inches focus, which cover a field of radius $4\frac{1}{3}°$. These photographs are taken with a view to obtain more accurate positions of the close polar stars used in determining azimuth error with meridian instruments.

During the year 1902 98 plates were measured, both in the direct and reversed positions of the plate, by two measurers, who measured the 6^m and 3^m images respectively. The part of the sky measured during the year comprises zone $+76°$ from R.A. 20^h to R.A. 0^h, zone $+77°$, zone $+78°$ (omitting about one hour), and zone 79° from R.A. 0^h to R.A. 1^h, the number of stars measured in this area being about 18,300. There has been a steady and remarkable increase in the number of stars per square degree in the different zones, as the following table shows :

Zone.	No. of Stars Measured.	Area in Square Degrees.	No. of Stars per Sq. Degree.	Zone.	No. of Stars Measured.	Area in Square Degrees.	No. of Stars per Sq. Degree.
64°	8,954	155	58	72°	10,080	108	93
65°	9,239	149	62	73°	9,120	102	89
66°	9,505	143	67	74°	8,720	96	91
67°	9,586	138	70	75°	9,310	90	103
68°	9,939	132	75	76°	8,800	84	105
69°	10,745	126	85	77°	8,500	78	109
70°	10,954	120	91	78°	8,100	72	113
71°	10,939	114	96	...	...	...	...

Altogether 898 plates out of 1149 have been measured, covering an area of 1710 square degrees out of 2088 ; thus 80 per cent. of the measurement is completed.

The measures of zone 71° have been printed during the year, thus completing the first half of the Greenwich zone. These measures, covering the part of the sky from Decl. 64° to 72°, form a volume of 732 pages.

During the year 51 chart plates have been counted ; the area between Decl. 65° and Decl. 70° is completed, and a paper on the statistics of the stars in this part of the sky was communicated to the Society last month. Zone 64° has been counted from R.A. 0^h to R.A. $1^h\ 40^m$.

Plate constants have been computed for the 132 plates whose centres are at Decl. 70° and Decl. 71°, and those for the plates

whose centres are at Decl. 72° are in progress. The standard co-ordinates of the reference stars were computed from a provisional catalogue derived from the Greenwich observations from 1897–1901, with very satisfactory results, showing that a very high accuracy will be reached when the observations of the reference stars by the transit-circle are completed.

As explained in a short note communicated to the Society last month it is proposed to reproduce the chart plates by purely photographic processes on double the scale. Fifty copies of each plate will be made and distributed among the 18 observatories contributing to the Astrographic Chart and to other important observatories and scientific institutions.

Photoheliograph.—Photographs of the Sun have been taken on 182 days with the Thompson photoheliograph of 9 inches aperture. Of the photographs taken 386 have been selected for preservation, including 21 with a double image of the Sun, taken to determine the position of the wires with reference to the parallel of declination. Photographs have also been received from India up to 1902 September 15, and from Mauritius up to 1902 June 20, the year ending on the latter date being represented on 357 days out of the 365 by a photograph from one or other of the three observatories.

The photographs taken at Greenwich have been measured in duplicate up to the end of 1902, and the measures reduced. The photographs from India and Mauritius have also been measured and reduced so far as received, and the copy for press written. The completion of the spot-ledger for the year, and the computation of the annual means, are waiting the receipt of photographs required to fill up gaps in the series since 1902 June 20.

The solar activity in 1902 has been very small, but has unmistakably increased since the previous year. The spotted area is distinctly larger than in 1901, and on 1902 September 17 a period of sustained activity set in. The faculæ too have shown a striking development since 1901; so that there can be no doubt that the period of minimum has been passed, and that the new cycle has been definitely entered upon.

Longitude of Paris.— Operations for the re-determination of the difference of longitude between Greenwich and Paris were carried out in the spring and autumn, observations being made simultaneously by two French and two English observers at adjacent stations. The observations, both in the spring and autumn, were made in three groups of three, six, and three full nights (or their equivalents in half-nights), the observers with their instruments being interchanged between the first and second and again between the second and third parts. The French observers were M. Bigourdan and M. Lancelin (M. Lancelin replaced M. Rénan, who was taken seriously ill soon after the commencement), and the English Mr. Dyson and

Mr. Hollis. The following table gives a summary of the number of nights of observation of the English observers:

	Date.	Observer at Paris.	Observer at Greenwich.	No. of Nights on which Signals were Exchanged.	No. of Fine Nights. Paris.	Greenwich.	Simultaneous P. & G.
I.	March 17–30 ...	D.	H.	13	5	9	4
II.	April 6–24 ...	H.	D.	19	9	11	6
III.	April 27–May 3	D.	H.	7	3	5	3
I.	Sept. 21–26 ...	H.	D.	6	4	5	3
II.	Sept. 29–Oct. 22	D.	H.	24	11	13	8
III.	Oct. 25–Nov. 4	H.	D.	11	8	6	5

The reduction of the observations is in progress.

The printing of the volume of *Greenwich Observations for* 1900 is completed with the exception of the introduction. The volume for 1901 is printed as far as the transit-circle ledgers. Copy for press of the transits and zenith distances observed with the altazimuth has been sent to the printers. The heliographic results are printed. The measures of the astrographic plates have been printed from Decl. 64° to Decl. 72° (about one-half of the part undertaken). The introduction to the volume, which will contain these measures, is nearly completed.

The rearrangement of the books and the new card catalogue of the general astronomical library have added considerably to its utility.

Royal Observatory, Cape of Good Hope.

In the last report reasons were given for the adoption of a new departure in the method of mounting the meridian marks of the new Transit Circle—by which the actual lines of azimuthal reference will be made to depend on marks attached to the bed-rock at considerable distances below the surface of the ground. The pits giving access to these marks must necessarily be water-tight. The original plan was to line the pits with cast iron; but, by order of the Admiralty Director of Works, an attempt was made in the first place to exclude water by brick and cement. This plan was tried for two pits but completely failed, and after considerable delay the plan of lining all the shafts with cast-iron cylinders was sanctioned. The lowest of these flanged cylinders, with thick cast-iron bottoms, have now been received, and the other open cylinders are being delivered from the Cape Town foundry at the rate of two per week, so that it is hoped this work will shortly be completed. It will then be possible to begin erection of the piers and houses for the collimators and marks, and to bring the instrument into regular use.

The investigations of the errors of all the micrometer screws have been completed, and a very thorough and satisfactory determination of the errors of the pivots has been made. The

pivots are of flint hard steel and their errors are quite considerable, but as the errors run very smoothly, and are completely determined with perfect agreement in the two positions of the axis, and are little liable to change, this is a matter of no consequence, as their effects will be completely eliminated in the reduced results.

The spectroscope of the Victoria Telescope has been, since November 1901, in the hands of the Cambridge Instrument Company, for the purpose of adapting four very transparent prisms in lieu of the three original prisms, which, as experience proved, absorbed too much of the rays of higher refrangibility. In addition to this alteration, new and very efficient automatic means have been applied for maintaining a constant temperature of the prisms.

The new Sidereal Clock—or rather, recording pendulum, swinging in a glass cylinder automatically maintained at constant temperature and pressure—is also approaching completion. The construction of this clock has been in the hands of the Cambridge Instrument Company since 1900, and it is now under trial. Mr. Lunt, being in England on leave, has been placed in charge of the tests and experiments connected with the spectroscope and clock, and has given most helpful aid to Mr. Horace Darwin in connection with that work. Zeiss, of Jena, reports that the $11\frac{1}{3}°$ objective prism of 24 inches aperture, presented by Mr. McClean, is ready for mounting; the $8\frac{1}{4}°$ Grubb objective prism and its mountings have been sent to Jena to be remounted in combination with the Zeiss prism.

The Cape Occultations 1881 95 (441 in number), reduced and compared with Hansen's Tables of the Moon, have been printed as Part 3 of Vol. II. of the Cape *Annals*. The Cape Day Numbers for 1904 are printed, and those for 1905 are in the press.

The Catalogue of 8560 stars for the Equinox 1900, to be used as standard stars for the Cape Astrographic Zone—Declination $-40°$ to $-52°$ is in press.

Parts I., II., and III. of Vol. IX. of the *Annals of the Cape Observatory* have been passed through press by Mr. Innes during his leave in England. The volume will contain the results of a revision of the *Cape Photographic Durchmusterung*, viz.:

Part I.—Results of examination of questions which have arisen from a comparison of other star-catalogues with the C. P. D.

Part II.—List of stars suspected by Prof. J. C. Kapteyn of variability, with the results of revision. Observations of variable stars. Miscellaneous stars examined. Observations of stars marked ? and *x* in the C. P. D. List of coloured stars observed in the course of the revision. Statistics of stars in the southern hemisphere to 9·0 magnitude inclusive.

Part III.—Errata in existing Southern Star Catalogues (for stars south of declination $-19°$).

Part IV. will consist of investigations on the proper motions of stars (chiefly stars suspected by Kapteyn of considerable

proper motion), but the work is delayed by non-completion of the necessary observations.

Vol. X., Part I. of the *Annals* containing Mr. Lunt's investigations on the spectra of silicon and oxygen has been passed through press by him in England.

The discussion of the heliometer triangulation of the southern circumpolar area, referred to in previous reports, has now been completed by Mr. Hough, and the manuscript has been forwarded to the printer. This discussion forms Part I. of Vol. XI. of the Cape *Annals*—a volume that will be dedicated to a discussion of all existing material bearing on the positions of the southern circumpolar stars. Part II. of the same volume will contain the discussion of a series of photographic plates covering the same area, the reductions involved in which are now well advanced.

The general work of the transit circle has been confined to observation of stars of the new working list (see Report, February 1900). The observations made have been :

Number of transits		7380
Determinations of Z.D.		6807
,,	collimation	95
,,	level	307
,,	azimuth	326
,,	run	291
,,	nadir	290
,,	flexure	23

The reductions of the meridian observations to apparent place are complete to the end of 1902, and to mean place till June 1902. Mr. Power has given considerable time to the investigation of questions raised by Dr. Ristenpart in connection with possible errata in the Cape Catalogues for 1840 and 1850. This work has been hampered by the fact that these MSS. were unarranged and in some part incomplete. The whole of these old MSS. are now being collected and bound.

Observations of 43 separate phenomena of occultations of stars by the Moon were obtained as follows :

	D.D.	R.D.
Phenomena predicted by the Nautical Almanac Office	15	10
Other occultations	18	
Total	33	10

Of these phenomena 7 were observed by 2 observers.

Comet Perrine has been observed on four mornings with the heliometer. The first observation was obtained on December 22 ;

the object is still under observation. A run of unfavourable weather prevented earlier observations.

With the 24-inch objective and Grubb object-glass prism of the Victoria telescope 280 successful star spectra (3·5 to 5·5 mag.) have been taken.

Experimental trials of enlarging lenses have been made, none of which have led to satisfactory results, but a number of very successful photographs of interesting objects have been secured in the primary focus of the telescope.

With the 18-inch visual objective of the Victoria telescope Mr. Innes has made 384 complete sets of measures (distance and position-angle) of 239 pairs of double stars.

In the course of the year 27 stars have been noted which were not previously catalogued as double, viz. :

11 pairs with the 18-inch,
8 „ „ 7-inch,
8 „ at the transit circle.

These new pairs have all been measured micrometrically.

During the year Mr. Innes has proved the variability of the two following stars :—

Name.	R.A. 1875. h m s	Dec. 1875. ° ′	Range of Mag.	Period.
C.DM. −42°,845	2 26 27	−42 0·8	10·0 to 11·5	260 days
C.Z. 3ʰ No. 721	3 24 22	−28 50·0	8·5 to 9·75	95 „ ?

The star *G. P. Z.* 7641, mag. 8·7, is found to belong to the category of stars having a regular nebulous envelope.

Very elaborate investigations of the spectra of silicon and oxygen have been completed, as well as investigations on the spectra of ε *Canis Majoris*, β *Crucis*, *Sirius* and *Canopus*, and on various sources of systematic error in line-of-sight work.

The following oppositions of major planets have been observed with the heliometer during the year :

	No. of Obs.
Opposition of Uranus	54
„ Saturn	33
„ Jupiter	31
„ Neptune	62 in two oppositions.* Early and late in 1902.

A new determination of the parallax of α *Centauri* has been undertaken by Messrs. Cookson and Lowinger, in connection with which 476 observations have been made in course of the year. Mr. Cookson has also continued his observations of the relative position-angles and distances of *Jupiter's* satellites. Of these

* See also Report for 1901.

he has obtained 570 observations on forty-eight nights in 1902. He has also completed the reduction and discussion of the whole of the observations of a similar series made in 1901; the reduction of the observations of 1902 is finished, together with the comparison of the observations with the corresponding tabular quantities; most of the coefficients of the unknown quantities are also computed.

With the Astrographic telescope the following work has been accomplished:

	No. of Plates.	No. of Exposures.	Duration of each Exposure.
			m m m
Triple exposure chart plates passed ...	103	309	30, 30, 30
„ „ „ rejected...	19	57	30, 30, 30
			m m s
Revision Catalogue plates passed ...	337	1011	6, 3, 20
„ „ „ rejected ...	114	342	6, 3, 20
Jupiter's satellites	48	556	5^s + trail
Adjustment plates—focus, orientation, &c.	14	...	various
			m
Galactic areas	7	14	10
Search for Ultra Neptunian planet ...	8	16	45

The plates of *Jupiter's* satellites have been taken for the same purpose as the heliometer measures.

The aperture of the object-glass was reduced by a diaphragm to six inches diameter. Every plate contains six exposures of the satellites each of five seconds, and six exposures of the standard stars of the same. The image of *Jupiter* was also allowed to trail across the plate; the satellites, except such of them as happened to be close to the planet, also recording their trails. It is hoped that these trails will furnish a valuable control on the inclinations of the orbits. The work of measuring the catalogue plates has been very seriously hindered by the resignation, early in the year, of five out of the six ladies previously employed on measurement, a result due mainly to the high rates of pay given in Johannesburg. The training of a new staff has cost much time. In consequence, only thirty-seven plates, containing 28,683 stars, have been measured during the year, as compared with 159 plates containing 100,203 stars, measured in 1901.

The total number of plates measured is now 434, containing 248,921 stars. The coordinates of every star have been measured in two opposite positions of the plate, and all the standard stars have been so measured by each of two observers. When either coordinate of any star differs by 0″·6 from the corresponding coordinate resulting from the measure in the reversed position of the plate, the observations in both positions of the plate are repeated.

Some progress has been made with the formation of a catalogue of the standard stars of the astrographic zone, based on

the two series of astrographic plates, so as to determine the approximate proper motions of such stars as have not been previously observed on the meridian. The necessary reduction-tables have been prepared, and the tabular rectangular coordinates have been computed for all the plates whose centres are $-41°$ and $-42°$.

The computation of the field work of the geodetic triangulation, so far as it has been carried out in Rhodesia, is nearly completed.

Field work there will be recommenced before the middle of 1903, on the arc along the 30th meridian between the Zambesi and Lake Tanganyika.

Field operations on the Anglo-German boundary between British Bechuanaland and German S.W. Africa were suspended in May, it being absolutely necessary to give the observers rest and change of climate. The northern part of the work proved peculiarly trying and difficult, and only possible of execution during certain months of the year. Major Laffan, R.E., the English Commissioner, has now returned to duty : he sailed from Simon's Bay for Swakopmund in H.M.S. "Pearl" on December 12, to meet his German colleague who went there direct from Germany.

Some idea of the difficulties encountered in the work may be formed from the fact that several of the stations are forty miles from the nearest known spring of water, and even that very unreliable in quantity.

The field work of the main triangulation is now finished. The angles have been reduced, the figures discussed, and the definitive geodetic latitudes and longitudes computed at the Observatory and supplied to the Commissioners. Some of the astronomical observations remain to be computed. The boundary from South Reitfontein to the Orange River has been beaconed, and if the season is favourable the remainder of the boundary will probably be demarcated during the next few months.

Mr. Heatlie, formerly engaged on the geodetic survey of Rhodesia, has been employed to assist Major Laffan in order to press on the work, and, if possible, to complete it during the short season that water melons are available, as the juice of this fruit is the only source of water supply in some of the arid districts traversed by the boundary.

The volume containing the re-reduction of Bailey's and Maclear's Survey has been distributed.

H.M. Astronomer, during a visit to Lord Milner at Johannesburg in July last, submitted plans for an Ordnance Survey of the Transvaal and Orange River Colony. These plans have been adopted, and Colonel Morris, R.E., C.B., has been appointed in charge of the work which is now being organised. The preliminary arrangements have thrown a large amount of work on H.M. Astronomer.

The records of the seismograph have been regularly forwarded

to Professor Milne, secretary to the Seismological Committee of the British Association.

The meteorological observations made during 1902 have been communicated to the Cape Meteorological Commission.

Mr. Hough, chief assistant, who was absent on leave in England from September 11, 1901, returned to duty on February 4, 1902.

Mr. Lunt has been on leave of absence in England (and subsequently on duty at Cambridge, as already mentioned) since May 7.

Mr. Innes has been on leave of absence in England since August 19.

Mr. Power has performed the secretarial duties of the Observatory in the absence of Mr. Innes.

Royal Observatory, Edinburgh.

The time service for the cities of Edinburgh and Dundee has been carried on as in former years, the various clocks concerned being under electric control from the Molyneux mean-time clock of this observatory. On six days in the course of the year the one o'clock gun was not fired, some part or other of the apparatus being under repair. One bad signal was made, the gun being fired one second too late on August 19th, owing to an accidental entanglement of the line wire. The time-ball was not raised on September 3 on account of the violence of the gale on that day.

Dr. Halm has continued his spectroscopic observations of the rotation of the Sun with the spectro-heliometer devised by him for the purpose, and the results so far, besides confirming Prof. Duner's well-known conclusions, seem already to indicate systematic changes in the angular momentum of the photospheric layers, probably connected with the Sun's activity. The method adopted by Dr. Halm appears to be of sufficient accuracy for detecting small variations of the Sun's rotational velocity, and it is hoped that the observations can be continued for several years in succession in order to test the character of the law of rotation at different phases of the sun-spot cycle. The 15-inch refractor was used by Dr. Halm for observations of comets and minor planets.

The computations of precession and secular variations of all the stars of the Henderson Catalogue have now been completed by Dr. Halm with the assistance of the temporary computer, and the results have been carefully checked. A comparison of the star places with the Fundamental Catalogue of the Astronomische Gesellschaft has been made by Professor Auwers, and at the same time independently by Dr. Halm, who has also compared the declinations with Professor Boss' Catalogue. It appears from these investigations that the transit observations of

the earlier period, 1835–40, are in better agreement with the Fundamental Catalogue than those made during 1840–45, and that the cause of the later discrepancies may perhaps be due to wear in the pivots. The declinations are in very close accordance with Boss' standard declinations. The discrepancies between the right ascensions and the declinations of stars observed in different years are on the whole larger than might have been expected. There can, however, be no doubt that this is partly due to outstanding errors in the instruments, especially to rapid temperature changes of the azimuth and level of the transit instrument, and accidental division errors of the mural circle. Dr. Halm is now engaged on a general revision of the work and comparison of the star places with other catalogues.

The transit circle has been under Mr. Clark's charge, the programme for the year including Sir David Gill's list of zodiacal stars and Cape heliometer comparison stars, besides the usual clock star list. The observations made during the year include 308 of clock stars, 614 of stars from the zodiacal list, 85 of heliometer comparison stars, besides 126 observations of stars for azimuth. The list of seventeen heliometer comparison stars for the 1903 opposition of *Jupiter* has been completed, each star having been observed five times, in accordance with Sir D. Gill's recommendation. Mr. Clark also observed the place of Nova *Persei* six times, and that of Comet *b*, 1902, three times with bright wire illumination. Determinations of the instrumental errors were made as frequently as possible, the collimation being measured thirty-three, level fifty-seven, and nadir sixty-seven times. Two special determinations were also made of runs and one of flexure. The results of these measures have shown the same marked constancy in the position of the instrument as was found in former years. The definitive reductions of the observations made with the transit circle at Blackford Hill have been taken in hand, and are making rapid progress. The observations of Nova *Persei* and of Comet *b* made during the past year are ready for publication.

The Milne Seismograph has now been in operation for over two years, and the resulting records of unfelt tremors have been as satisfactory during the past year as in the preceding. Traces of fifty-two earthquakes which occurred during 1902, varying in amplitude from 0·25 mm. to 22·0 mm., have been found on the photographic rolls. In duration they have varied from a few minutes in the case of disturbances of small amplitude to between three and four hours for the more pronounced movements. The most remarkable records are those of the earthquakes in Guatemala on April 19 and September 23, and of that in Kashgar on August 22.

The usual meteorological observations have been carried on by the staff of the Observatory as formerly, and copies of the readings have been supplied to the Registrar-General for Scotland and to the Scottish Meteorological Society. The

Robinson anemometer curves have been regularly tabulated by Mr. Clark.

A watch for the Leonid meteors was kept during the whole night of November 15 by the staff of the Observatory, but without success. This was the only fairly clear night near the epoch of the meteors.

The 24-inch Grubb reflecting equatorial has been used by Mr. Heath for photographing nebulæ.

Cambridge Observatory.

Meridian Circle.—Owing to unfavourable weather and unavoidable delays the meridian circle was used for observations during the year 1902 on only twenty-six nights.

From the beginning of the year to the middle of June the work was chiefly confined to the observation and reduction of Sir David Gill's Catalogue of 2798 zodiacal stars : 1690 complete observations were made in the right ascension and declination of these stars, including 392 observations of clock stars.

On 1902 June 17 the observation of Sir David Gill's second list of heliometer comparison stars was begun, and 572 complete observations were made, including 112 of clock stars. The work was delayed by the collapse of one of the spider lines in the eye end. On August 11 it was found that G, one of the supplemental wires used in observing circumpolars, had broken, curled up, and fallen on its neighbour, wire V, one of the seven used in observing quick stars, so that both wires were rendered useless. The vertical wires were replaced by a fresh set of spider lines at the works of the Cambridge Scientific Instrument Company, and eighteen nights, from August 14 to September 16, were devoted chiefly to the observation of circumpolars, to obtain material for the computation of the equatorial intervals of the fresh set of wires. Provisional intervals were calculated from fifty-nine observations of close circumpolar stars, and 305 of more distant, made 1902 August 14–October 4, and have been used from August 14 to the end of the year : when a fresh determination has been made from 109 observations of circumpolars and 841 observations of quick stars.

The observation of the heliometer comparison stars and of the zodiacal stars was resumed on September 17.

The total number of observations made during the year is 2902, comprising 1690 of zodiacal stars, 572 of heliometer comparison stars, 353 of clock stars, and 287 of circumpolar stars, including fifty-six of *Polaris* at the upper transit and seventy-five at the lower.

The work of reducing these observations is well advanced. The reductions are completed to mean equinox at the beginning of the year to 1902 June 18, and to apparent right ascension and apparent declination to the end of October.

The results of the observations made for the catalogue of zodiacal stars have been collected and arranged in order of right ascension. They comprise observations of 1785 stars. Of the remaining stars in the catalogue 116 are fundamental stars and eighty-six are too far south to admit of their being observed with the Cambridge meridian circle. There are thus 812 stars in the catalogue remaining to be observed.

The nadir point, level, and line collimation have been regularly observed, and the constants for instrumental correction obtained 229 times, each time chiefly from two equations, sometimes from three—in all 476 equations.

Sheepshanks Photographic Equatorial.—Since the last report to the Society considerable progress has been made with the reduction of *Eros* photographs for a new determination of the solar parallax. In June an account was given of the second part of an experimental reduction of a small number of photographs made nearly simultaneously at Mount Hamilton, Minneapolis, and Cambridge. Two conclusions were drawn from this instalment of the work—(1) that the method of reduction in rectangular coordinates throughout was so far successful as to be worthy of a more extended trial ; and (2) that it was very desirable that all the photographs made at different observatories should as far as possible be combined into one solution. A request was therefore made to the directors of some ten observatories that they should measure their *Eros* photographs obtained during the nine days 1900 November 7–15 inclusive, and send the measures to Cambridge, with permission to combine them into one solution for a further trial of the methods used in the preliminary reductions. A very kind and ready response was made to this request, and a good deal of material has already reached Cambridge. We are indebted to the directors of the observatories of Paris, San Fernando, and Algiers for measures of the planet and of the *étoiles de repère* on all their plates taken during those nine days ; and results from a number of other observatories are promised, and will be shortly available. We are indebted to M. Lœwy for the publication (circular No. 9) of separate heliocentric ephemerides of the planet to the Earth.

With the aid of a grant from the Government Grant Fund of the Royal Society we have been able to secure the help of two ladies, formerly students of Girton College, as computers. The first step is to form a uniform system of places of the comparative stars by combining measures or overlapping plates. This work is well in hand.

With the telescope a beginning has been made of a series of photographs of selected fields for the determination of stellar parallax.

The Newall Telescope, Cambridge Observatory.

The Newall telescope was used for observations on 61 nights in the course of the year 1902, this having been the most unpropitious year for observations since the instrument was installed at Cambridge.

The instrument has been used throughout the year in connection with the four-prism spectroscope, which was readjusted in January, in place of a two-prism spectroscope that had been in use most of the previous year. Special attention has been devoted to the spectrum of *Sirius*, *Procyon*, and *α Persei*, but otherwise the work has been confined to stars which occur in the short list adopted in the plan of co-operation recently inaugurated between some of the observatories engaged in "line-of-sight" work. The year has been unfavourable for photographic work ; 98 photographs of stellar spectra have been obtained ; and in addition to these about fifty have been rejected on account of insufficient exposure or interruption by clouds. In the laboratory about 200 spectra have been photographed, partly in the process of testing the adjustments of the spectroscope, and partly in the study of the spectrum of magnesium, specially with a view to the determination of the wave length of the blue line at 4481 λ. This line has, after much experimenting, been obtained narrow and defined enough for exact determination of the wave length.

A gas engine and dynamo have been installed in the north annex for use in spectroscopic observations.

Dunsink Observatory.

The observations of Sir David Gill's zodiacal stars are now completed. These were commenced in 1900 January, and of the 2798 stars on the list about 2100 have received at least four observations, while about 300 have been observed less than four times. The months of June, July, and August in each year were extremely unfavourable for observation, and accordingly very few stars between 14^h and 18^h R.A. have been cut out. With every probability of similar weather in succeeding years it did not seem to be desirable to prolong the work in order to fill up this gap. The total number of these observations amounts to 20,367, and consists of 10,378 in R.A. and 9989 in Decl., arranged as follows :—

R.A.		Decl.	
Zodiacal stars ...	8,932	Zodiacal stars ...	8,932
Standard stars ...	877	Standard stars ...	796
Azimuth stars ...	177	Nadir	190
Collimation... ...	190	Runs	71
Level	202		
Total in R.A. ...	10,378	Total in Decl. ...	9,989

The observations have been reduced to apparent place in R.A. to 1902 August 27, and in declination to 1901 October 21.

During the year 1902 the number of observations made with the meridian circle is 7516, consisting of 3346 observations in R.A. of the zodiacal stars, 299 observations of *Berliner Jahrbuch* stars for clock correction, 61 determinations of level and 61 of collimation, while 54 stars were observed for azimuth error. In declination 3346 observations were made of the zodiacal stars, 258 stars were observed for the equator point of the circle, 61 determinations were made of the nadir point and 30 of the error of runs. In order to carry on the reductions observations with the meridian circle were discontinued in the latter part of the year except for determinations of clock error.

The Roberts telescope has been used throughout the year in photographing clusters, and some photographs of the comet 1902 *b* were also obtained.

The South equatorial has principally been used in showing visitors objects of interest on the first Saturday of each month.

The time service to Dublin has been carried on as heretofore, and the time ball on the Port and Dock Office has been let fall daily at 1^h G.M.T.

Durham Observatory.

During the past year 663 transits have been taken with the Almucantar upon forty-four nights. The reduction of these is almost completed, and it is hoped shortly to publish an account of them.

The Almucantar has been provided with a wind screen, which makes it possible to observe with it on many nights when the wind would otherwise have been too high.

A great deal of time has been devoted to the discussion of the Harvard observations of eclipses of *Jupiter's* satellites. The whole of the observations have now been charted and the charts measured.

Duplicate calculations of the equations of condition and other requisite quantities, besides some considerable theoretical discussions have been pushed on and are now well advanced. The work has been much facilitated by a grant from the Government Grant Committee. A portion of the theoretical discussion has already been passed for press.

Meteorological work has been carried on as heretofore.

Glasgow Observatory.

Two faint stars in the immediate vicinity of the pole, and α and λ *Ursæ Minoris* were measured with the transit circle in continuation of the work begun in 1897. Owing to the prevailing

unfavourable weather, two or more observations of the faint stars were obtained only on eighteen nights.

The spectrograph, mounted on the 20-inch Breadalbane Reflector, was exclusively used in photographing the spectrum of Nova *Persei*. From January to May five plates were secured with exposures varying from six to sixteen hours, the last plate being exposed on seven nights—from April 1 to May 2. The work was taken up again in autumn, and a plate exposed for twenty-three hours on four nights between October 20 and November 1 shows, though faintly, the same lines as were photographed at the beginning of the year. A second plate was exposed for twenty-three hours on November 17, 18, 20, and 21; but owing to the continuous bad weather in December (and also in 1903 January) it has not yet been possible to complete the exposure. The plates of 1901 and 1902 have been measured, the work entailing about 25,000 settings. The points measured have been identified and the reduction to wave-length is almost completed.

Time observations were taken on 101 nights, and the meteorological work has been carried on as in former years.

Liverpool Observatory, Bidston.

The course of observations which has been pursued in earlier years, one adapted to the requirements of the port and the character of the instruments, has been followed without interruption, but without addition, throughout the year. Very considerable attention has been paid to the testing of chronometers and other apparatus for which the Board grants certificates of test: to the distribution of time signals, and to meteorological inquiries. These latter seem to be particularly welcome to the local medical officers of health, and in connection with a recent suggestion that meteorological observations should be suspended for a period of years it seems not undesirable to call attention to a class of scientific men who would apparently suffer if deprived of certain climatic constants.

In the astronomical department, properly so called, the observation of comets has been systematically pursued, and some attention has been given to the observation of double stars. The comets of Perrine and Giacobini have both been observed, and the observation of double stars has been practically limited to those binary systems for which moderate optical means suffices. Concurrently with these inquiries the series of seismological observations is maintained, and a comparison of the results obtained with those recorded at Hamburg and Strassburg shows that the site is admirably adapted for a seismological station. In two out of the three terms lectures are given at the observatory in connection with University College.

In the course of the year the solicitor of the Dock Board gave notice of an intention on the part of the Board to seek powers from Parliament relieving the Trust from its statutory obligations in the matter of maintaining the Observatory. The Board, however, has not seen fit, at present, to prosecute this aim, and the Observatory remains under the same care and maintenance as heretofore.

Radcliffe Observatory, Oxford.

The work done with the Transit Circle during the year has been confined to filling up gaps in the working list of stars described in the Report of this Observatory communicated to the Society in 1900 February, and 1215 transits and 1084 zenith distances have been observed. The reduction of observations, which was still in arrears at the date of the last report, has been pushed on persistently and is now in a very forward state. All the zenith distances have been completely reduced to the end of the year. The right ascension observations have been completely reduced up to 1902 April 28, and the reduction from that date to the end of the year is well in hand.

The definition of the wires in the Transit Circle collimators has been considerably improved by some small alterations which have had the effect of facilitating the determination of horizontal flexure of the instrument, and reducing the effect of personality upon it.

A further attempt was made to determine the pivot errors of the Transit Circle with the arrangement described in the report of this Observatory for the year 1900. The principal difficulties referred to in that report were got over by the use of a good $6\frac{1}{2}$-inch objective for the collimator, kindly lent for the purpose by Sir Howard Grubb. It was found, however, that the reflected image of the wires was affected by a slight swaying movement, due possibly to movements of the ground. As this movement more than masked the small effects of pivot error which we were in search of, and as there appeared no way of eliminating it, the observations have been discontinued.

The Barclay equatorial telescope has been chiefly used for the observations of Nova *Persei*, and determinations of the brightness of this star have been obtained on January 4 and 28 February 10, March 12 and 29, September 3, 5, and 6, and December 31. The results of these observations as far as March 29 were communicated to the Society in June. Nova *Aurigæ* and Comet *b* 1902 (Perrine) have also been observed with this instrument ; and the observations of comet Tempel 2, 1899 IV., have been reduced and published in the *Monthly Notices*, vol. lxii. No. 9.

The erection of the new photo-visual refractor has occupied a great deal of time and required a large amount of attention

during the year. The main castings were delivered in Oxford on February 21, and placed in position on March 16. This mounting of the other heavy parts, the axes, crosshead, and tubes, was completed towards the middle of May, when the scaffolding was taken down and the work on the lifting floor was pushed on and completed. Some difficulties arose in this part of the work, but they were all successfully surmounted and the floor now works most satisfactorily. It can be set at any height to a small fraction of an inch, and can be kept there without any sensible "creep" for an indefinite time. The adjustment of the train of prisms and lenses for enabling the R.A., as well as the declination, circle to be read from the eye end through the declination axis was another part of the work of erection which gave a good deal of trouble, but in the end was very satisfactorily accomplished. Early in November the polar axis of the instrument was brought into very approximate adjustment, using a 7-inch finder, which is mounted on the 24-inch tube, but the 24-inch and 18-inch objectives were not inserted in the tube until November 22.

Meteorological observations and automatic registrations have been maintained as usual, and the observation of underground temperature by means of platinum thermometers has been carried on uninterruptedly.

University Observatory, Oxford.

The work of measurement and reduction of plates for the Astrographic Catalogue is approaching completion. The total number of plates completely reduced on December 31 was 1025 out of 1180, the year's work being represented by 126 plates, many of them rather thickly studded. The remaining 155 being in regions of the sky not rich in stars, it is hoped to finish them during 1903. The measures of the *Eros* plates have accordingly been put aside for the present, but will be resumed as soon as the majority of the remaining plates are finished, if funds can be provided for the purpose.

A good deal of experimental work has been done preparatory to interpreting the measured diameters of the star discs in terms of stellar magnitude. Among other things it has been shown indirectly that the diameter is sensibly affected by the distance from the centre of the plate, for the number of stars photographed varies with this distance to the extent of 50 per cent., corresponding to about a whole magnitude (*Monthly Notices*, vol. lxii. p. 434).

An examination of the differences between the places of stars deduced from our measures and the Cambridge meridian observations made from 12 to 22 years earlier has given some valuable information on an important point, raised by Sir David Gill, concerning the systematic motion of bright stars relatively to

faint. This work is still proceeding, but some results have been published (*Monthly Notices*, vol. lxiii. p. 56).

Mr. F. A. Bellamy, on whom has fallen the heavy work of superintending all the reductions for the Astrographic Catalogue, has nevertheless found time to continue his work on stellar distribution. Some points of interest which arose in the course of it have delayed publication.

Mr. H. C. Plummer, M.A., has continued his investigations on the measurement of star images photographed with different instruments (*Monthly Notices*, vol. lxii. pp. 352, 506; vol. lxiii. pp. 14, 16). The result, as regards the parabolic reflector, is somewhat disappointing, for the hope that a study of the geometrical theory would suggest a method of diminishing systematic error in measurement has so far not been realised, but it is hoped that the large amount of work done may serve its purpose in clearing the ground for others. Two short papers by Mr. Plummer on points of mathematical interest have appeared during the year (*Monthly Notices*, vol. lxii. p. 545; vol. lxiii. p. 90).

The work of reducing the Rousdon Observatory observations of variable stars has proved unexpectedly heavy, though it is now approaching completion.

This report would be incomplete without a reference to the excellence of the work done by Mr. B. Gray and Mr. E. A. Gray in measuring and reducing our astrographic plates. Their work, always careful and good, has improved with experience until it has now reached a very high standard of excellence.

Temple Observatory, Rugby.

The object of this Observatory is to give boys a taste for astronomy, and, judging from the increased attendance during the past year, it is doing its duty. From twenty to thirty boys came nearly every fine evening during the autumn months. The measurement of double-stars has been continued as before.

Stonyhurst College Observatory.

The solar surface was observed on 217 days of the past year, 1902, very evenly distributed throughout the twelve months. Drawings were made on 110 days, and on the remaining 107 days careful searching could find no disturbance. The longest period of solar calm was from June 2 to September 18. From September 23 to November 25 there was an appearance of a gradually increasing activity; but throughout December the surface was perfectly calm.

The deduced mean spotted disc-area for the year was 0·33 (the unit being $\frac{1}{5000}$th of visible disc), which is in favour of

returning activity. In the three years 1900–2 the mean areas were respectively 0·55, 0·29, 0·33.

The magnetic variations have been, on the whole, small, and afford no indication of the end of the minimum period. The mean daily range of the declination magnet was closely the same as for the preceding year, being 9′·0, against 9′·1 for 1901. The greatest disturbances occurred on January 15, April 10, and August 21, with extreme oscillations of 32′, 35′, and 36′ respectively. These are compared with the solar surface in the following table :—

Date. Range.	Dates. Spotted Disc-areas.		
Jan. 15 32′	Jan. 9, 13, 14 4·0 1·0 0·6		Jan. 25 to Feb. 12 0
Apr. 10 35′	Mar. 3 to Apr. 9 0	Apr. 10 0·1	Apr. 11 to May 23 0
Aug. 21 36′	July 29 to Aug. 23 0	Aug. 24 0·2	Aug. 25 to Sept. 18 0

The stellar spectrographic work has made but slow progress during the year, owing mostly to the generally cloudy state of the sky after sunset, many of the most promising evenings having failed in this way. About 150 exposures were made, including some purely experimental trials of focus. Of these sixty-six were directed to *β Lyræ*, on the 4-inch prismatic camera, and forty-four plates have been selected for a supplementary paper on the violet end of the star's spectrum. These have been enlarged and mounted, and are ready for a comparative study ; but other pressing obligations in the physical laboratory will probably delay this and other reductions until more material has been collected.

Mr. Edward Crossley's Observatory, Bermerside, Halifax.

There has been no change in the work of this observatory since the last report. As in previous years it has consisted mainly in the observation of *Jupiter*, the measurement of binary stars, and the usual daily meteorological observations for the Registrar-General, &c.

Wolsingham Observatory (Rev. T. E. Espin's).

The work of measuring double stars has been continued, as in the previous year. The amount of clear sky, especially during the latter part of the year, has been much below the average, and the definition has been generally poor. The results of measures made in the earlier part of the year, together with those in

previous years, were published in *Monthly Notices*, vol. lxii. No. 7. The total number of measures made during the year is 1496. 38 new pairs have been detected.

Sir William Huggins's Observatory, Upper Tulse Hill.

The photography of stellar spectra, which has been in progress for some years, has been continued during the past year.

In the laboratory metallic spectra have been photographed under different experimental conditions in connection with the Observatory work. A preliminary note on the changes of character of the magnesium line at λ 4481 has been published in the *Astrophysical Journal.*

Rousdon Observatory, Lyme Regis, Devon.
(*Late Sir C. Peek's; C. Grover, Observer in Charge.*)

The building has been repainted during the summer, and the instruments are maintained in good working order. The year as a whole has been by no means favourable for astronomical work. The four months April to July, with September and October, were very good for observation, but the remaining six months were very poor. Observations were made on 148 nights, which is somewhat below the average number; but by extended watches on these nights the total amount of work accomplished is nearly up to the average. The 6·4-inch Merz equatorial has been kept at the observations of long-period variable stars; 558 magnitude determinations have been made. Argelander's method has been followed as during the previous sixteen years. At each observation the light of the variable is estimated relatively to five comparison stars in the same field of view, the mean result being assumed to be the magnitude on the date of observation. Thus during the year 1902 about 3000 observations of stellar brightness have been made, and eighteen maxima and seventeen minima have been recorded. About twenty-five long-period variables are under regular observation, and, as most of these are circumpolar in this latitude, their light changes are continuously recorded.

Transits of stars are taken as often as required for the regulation of the sidereal clock and mean time chronometer.

Comet *b* 1902 (Perrine) was observed on seventeen nights between September 12 and November 12. During the first half of October it was a very interesting telescopic object; the principal tail was a long straight ray, on either side of which fainter streams of nebulous matter were seen, giving a distinct three-rayed aspect. The Lunar eclipse on the morning of October 17 was also well seen.

Dr. Isaac Roberts's Observatory, Crowborough Hill, Sussex.

The following list of nebulæ, &c.—the eleventh of its kind—comprises those objects which have been photographed in the course of the year 1902. The weather, on the whole, has not been quite so favourable for photographic work as in some previous years. The 20-inch mirror was resilvered during the past summer, and the film is now in excellent condition. Six photos of Perrine's comet were obtained between September 6 and October 10, with exposures varying from fifteen to ninety minutes.

List of the principal Photographs taken in 1902.

	Approx. R.A. h m	Decl. ° ′	Expos. h m
Neb. H III. 868 Piscium	0 3	+ 4 3	1 30
Neb. *h* 29 Andromedæ	0 28	+45 57	1 30
Neb. H II. 707 Andromedæ... ...	0 33	+47 47	1 30
Neb. M. 31 Andromedæ	0 37	+40 43	1 30
Neb. M. 74 Piscium	1 31	+15 16	2 0
Neb. H II. 211 Arietis	2 28	+28 52	1 30
Region of *Nova* Persei	3 24	+43 34	2 54 (Jan. 5) 1 30 (,, 12)
Neb. H IV. 69 Tauri	4 3	+30 31	1 30
Index Cat. 405 Persei	5 9	+34 13	1 30
,, ,, 410 ,, ...	5 16	+33 25	1 30
,, ,, 417 ,, ...	5 21	+34 22	1 30
,, ,, 419 Aurigæ	5 24	+30 4	1 30
,, ,, 425 ,, ...	5 30	+32 22	1 6
Neb. M 42 Orionis	5 30	− 5 27	0 30 0 15
H's Nebulous Region No. 24 ...	5 32	− 4 18	1 30
Star magnitudes near ϵ Orionis ...	5 35	− 1 16	1 30
Index Cat. 439 Aurigæ	5 50	+32 0	1 30
H's Nebulous Region No. 28 ...	6 1	+ 3 44	1 30
,, ,, ,, ,, 29 ...	6 1	−20 27	1 30
Neb. H V. 21 Canis Majoris ...	7 13	−13 2	1 30
Neb. H II. 554 Cancri	7 56	+16 0	1 30
Neb. H III. 877 Monocerotis ...	8 1	−11 8	1 30
Neb. H III. 488 Hydræ	9 15	−16 0	1 30
H's Nebulous Region No. 31 ...	9 27	−18 27	1 30
Neb. H III. 254 Sextantis	9 48	+ 2 3	1 30
Neb. H II. 492 Leonis Minoris ...	9 52	+32 51	1 30
Neb. H II. 43 Leonis	10 8	+23 14	1 30

	Approx. R.A. h m	Decl. ° ′	Expos. h m
Neb. H II. 28–9 Leonis ...	10 18	+20 24	1 30
Neb. H IV. 27 Hydræ ...	10 20	−18 8	0 41
Neb. H II. 77 Leonis... ...	10 40	+14 17	1 30
Neb. H II. 101 Leonis ...	10 55	+14 26	1 30
Neb. H V. 39–40 Hydræ ...	10 58	−22 38	1 30
Neb. H I. 246 Ursæ Majoris	11 22	+57 26	1 30
Neb. H I. 287 Draconis ...	11 30	+71 5	1 14
Neb. H IV. 67 Ursæ Majoris	11 50	+59 2	1 30
Neb. H IV. 62 Ursæ Majoris	11 51	+55 42	1 30 (two)
Neb. H I. 196 Canum Venaticorum...	12 4	+44 14	1 30
Neb. H I. 208 Ursæ Majoris	12 6	+51 2	1 30
Neb. H I. 209 Canum Venaticorum...	12 11	+48 26	1 30
Neb. H I. 91 Comæ Berenicis	12 23	+29 10	1 30
Neb. H I. 254 Ursæ Majoris	12 35	+62 10	1 30
Neb. H I. 142 Virginis ...	12 40	+ 3 26	1 30
Neb. M 51 Canum Venaticorum ...	13 25	+47 43	1 0 0 30 (three) 0 15 („)
Neb. H II. 297 Virginis ...	13 32	−17 22	1 30
Neb. H II. 538 „ ...	14 39	+ 2 6	0 50
Neb. II. 587 Ophiuchi ...	17 40	+ 3 13	1 30
Star chart in Hercules ...	18 2	+27 35	1 30
Index Cat. 1274–5 Sagittarii	18 3	−23 48	0 55
Neb. H I. 47 Aquilæ... ...	18 47	− 8 50	2 0
N.G.C. 6757 Draconis ...	19 2	+55 34	1 30
Neb. H IV. 14 Aquilæ ...	19 9	− 2 53	2 0
N.G.C. 6821 Aquilæ	19 39	− 7 3	1 30
Neb. H II. 878 Draconis ...	19 41	+55 52	1 30
Chart of stars in Cygnus ...	19 45	+35 30	1 0
N.G.C. 6942 Cygni	19 51	+28 59	1 30
N.G.C. 6852 Aquilæ	19 55	+ 1 27	1 30
N.G.C. 6906 Aquilæ	20 18	+ 6 8	1 30
N.G.C. 6911 Draconis ...	20 18	+66 35	1 30
Neb. H III. 142 Aquilæ ...	20 26	− 2 26	1 30
N.G.C. 6928 Delphini ...	20 28	+ 9 35	1 30
N.G.C. 6951–3 Cephei ...	20 36	+65 54	1 30
N.G.C. 6969 Delphini... ...	20 43	+ 7 21	1 30
Region near 60 Cygni ...	20 58	+45 45	2 50
Neb. H IV. 74 Cephei ...	21 0	+67 46	1 30 1 0 (two)

	Approx. R.A. h m	Decl. ° ′	Expos. h m
N.G.C. 7026 Cygni	... 21 3	+47 27	1 30
H's Nebulous Region No. 42	... 21 3	− 1 53	1 30
Neb. H III. 858 Equulei ...	... 21 10	+ 2 25	1 30
N.G.C. 7116 Cygni	... 21 38	+28 30	1 30
Neb. H II. 476 Aquarii ...	... 22 29	−10 52	1 30 2 0
Neb. *h* 2176 Pegasi	... 22 35	+10 30	1 30
Neb. H II. 477 Aquarii ...	... 22 41	−11 32	1 30
Neb. H II. 453 „ ...	... 22 46	− 6 6	1 30
Neb. H III. 745 Cephei ...	... 22 51	+56 35	1 30
H's Nebulous Regions Nos. 50 and 51	22 57	+25 45	2 0
Neb. H III. 558 Aquarii ...	... 23 3	−16 10	1 30
Neb. H III. 233 Piscium ...	... 23 48	+ 7 25	1 30
Neb. *h* 2302 Cassiopeiæ ...	... 23 59	+67 7	2 0 (two)

Comet *b* 1902 (Perrine) 90^{m}, 60^{m}, 45^{m}, 60^{m}, 15^{m}, 52^{m}.

Mr. Saunder's Observatory, Crowthorne, Berks.

With the assistance of Mr. J. A. Hardcastle, F.R.A.S., progress has been made with the measurement of two of the Lunar photographs kindly lent by M. Loewy. Much work done during the early part of the year had to be rejected, as serious errors were found in the réseau employed. This réseau was made in England, and had been kindly presented to the University Observatory, Oxford, expressly for this work, the diameter of the Moon on the Paris plates being such as to require a réseau larger than those in use for the astrographic plates. Finally a new large réseau was obtained from M. Gautier, and has given entire satisfaction. A further delay was caused by the slipping through 0·003 inch of the copy of this réseau attached to one of the plates during the progress of the measurements. (See *Monthly Notices*, vol. lxiii. p. 73.) The epoch at which the greater part of the shift occurred has been ascertained, and suitable corrections applied to the readings. It is hoped that work now in progress will determine the epochs at which the rest of the shift occurred, and enable the measures of 500 points made on this plate to be saved ; also that the method now adopted for securing the réseau will prevent the occurrence of similar accidents in the future. On the other plate some fifty points have been measured and the plate constants found. This work has been rendered possible by a grant made by the Government Grant Committee of the Royal Society.

The telescope has been employed chiefly on the Moon. A series of measures has been made of the white spot surrounding

the crater Linné, which it is believed will confirm the announcement made by Professor W. H. Pickering that the diameter of this spot varies with the progress of the Lunar day. Progress has been made with the map of *Ptolemæus*, and the telescope has also been used for comet-sweeping.

Mr. W. E. Wilson's Observatory.

In the early spring a set of duplicate photographs were taken for the search for an ultra Neptunian planet. These were carefully compared with the set taken the previous year, but with a negative result. The plates cover the region of the sky in which the researches of Forbes, Todd and Lau, all locate the position of such a planet.

The weather during the year has been even worse than the previous year, and practically no work could be done with the 24-inch reflector. Rain fell on 246 days, and the quantity of cloud was abnormal. During the summer the new pyrheliometer was calibrated with Angström's standard instrument, and it now gives a reliable record of the solar radiation.

Melbourne Observatory.

Meridian Observations made with the 8-inch Transit Circle.

	R.A.	N.P.D.
Azimuth stars	298	138
Clock ,,	414	...
List ,,	734	740
Zodiacal ,,	1083	1077
	2529	1955

The list stars were, as in previous years, selected from the Melbourne plates of the Astrographic Catalogue, to be used as standard reference stars for the reduction of those plates.

The zodiacal stars were selected from the list of heliometer comparison stars published by Sir David Gill, 1901 April 2. The observations covering the full list will be completed by the end of the current year.

Reductions.—The separate results and annual catalogue for 1901 have been completed, and the reductions of observations made in 1902 are nearly up to date.

The total number of standard stars for the reduction of the Astrographic Catalogue plates which have been completely observed with the 8-inch transit circle three times or more is 4085.

Astrographic Operations.—

Chart plates with triple exposures of 30^m each	... 143
Catalogue plates (second series)	... 139
Test plates on south polar regions	... 43
Test plates on Oxford type regions	... 12
Test plates for centre, focus, trails, &c.	... 32

Eleven chart plates and two catalogue plates were rejected as defective.

The state of this work to December 31st, 1902, is as follows:—

Chart plates with triple exposures of 30^m each, passed as satisfactory	... 244
Chart plates with single exposure of 60^m each (complete)	—
Catalogue plates (complete)	... —
Catalogue plates (duplicate series)	... 139

A careful examination of the contact prints on glass, of the series of our chart plates with single exposure of 60^m, which were obtained towards the end of 1901, has shown that these positives are very defective, the faults arising chiefly from impurities in the water used for washing the original negatives, and dust, settled on them while drying.

In order to remedy these faults as far as practicable the system has been adopted of using only thoroughly filtered water for washing the plates, and drying in a closed box over a tray containing pieces of chloride of calcium. With these precautions we now obtain much better results.

Other Observatory work during the current year comprises, as in previous years—

The State weather service, with the control of 800 recording stations.

The Time service.

The Tide service.

Terrestrial magnetism, including the carrying out of the full programme prescribed by the Royal and Royal Geographical Societies for co-operation in 1902–03 with the Antarctic Expeditions, and the measurement and reduction of some 6100 daily magnetic curves covering the period 1875–1880.

Registration of seismic disturbances by means of the Milne horizontal pendulum, which has been regularly at work since March 1902, and of seismic disturbances reported by observers at various recording stations in the Commonwealth.

The reduction of arrears of astronomical observations, cloud photography, and climatological statistics, and many other minor duties for public local requirements.*

The State standards of Weights and Measures, and all the stock of copies for issue to the Municipalities; balances, apparatus,

* Rating of chronometers, and testing nautical, meteorological, and surveying instruments.

and accessories for verification and adjustment were last September transferred to the Observatory, and all technical work related to the Administration of the Victorian Law on Weights and Measures has since formed part of the duties of this Institution, by order of the Government.

There is some hope that the Metric system may soon be introduced in Australia.

No changes in the staff have taken place. The position of Chief Assistant is still vacant, and there seems to be no prospect of filling it this year.

Measurement of the Sydney and Melbourne Plates of the Astrographic Catalogue. Joint Report for Sydney and Melbourne.

This work was carried on by the Measuring Bureau at the Melbourne Observatory, using the Gill-Repsold measuring instrument, and the Melbourne filar micrometer-machines, as in previous years. The second Gill-Repsold measuring instrument, which was ordered in 1900, reached the Observatory at the end of last September. This second apparatus is similar to the first in design, dimensions, and excellence of workmanship, and is highly satisfactory in every respect.

A new room for the astrographic measuring bureau was erected in the course of the year, and was ready for occupation by the end of December. This interfered a little with the progress of the work ; but the new room is a great improvement, and the work is now carried on far more comfortably and satisfactorily than in the old building, which was far too small.

The measurements made during the year ending December 31st, 1902, were as follows :—

83 Sydney plates, containing 24,142 stars, completely measured in the direct and reverse positions.

194 Melbourne plates, containing 58,988 stars, also completely measured in the two positions.

The total numbers of plates completely measured up to date are as follows :—

224 Sydney plates, containing 131,061 stars, or an average of 585 stars per plate.

293 Melbourne plates, containing 83,482 stars, or an average of 285 stars per plate.

Perth Observatory, West Australia.

Progress in the Astrographic work has not been so rapid as was expected, for two reasons :

Owing to some difficulty in procuring reliable plates for the chart series no work was done with this instrument between February 6 and April 24 ; and in September the Government

Astronomer was officially informed that all astronomical work not required for local purposes must cease on December 31. This naturally caused disorganisation. No fresh plates were ordered and each of the officers obtained his accumulated leave of absence ; so that very little has been done during the last three months. Notwithstanding these serious interruptions 52 triple chart and 96 catalogue plates have been taken.

When the proposed discontinuance was reported the Royal Society made representations to the British Government, and as a result the matter will probably be reconsidered by the West Australian Government, and it is hoped that now they realise its importance they will see their way to authorise the completion of the work. Just at present, however, nothing is definitely settled.

Measurement of Plates.—Unfortunately this has not been commenced, and there seems little chance of the Perth Observatory being able to undertake it.

Transit Circle.—Work with this instrument has progressed steadily. The working scheme includes three stars per degree where possible, or twelve per plate, for zones 31° to 40°. Each star is to be observed three times in R.A. and N.P.D. (using four microscopes), and it is desired to take two degrees per year. The zones 31 and 32 (31° 0′ to 33° 0′ south declination) are completed, with the exception of a few scattered observations, and reduced. In a number of cases three suitable stars could not be found in the degree, and the total number for the above two zones is 1632.

At the request of Sir David Gill the zones 40° and 41° are now being taken, and in these 236 stars have been completely observed. The reductions are well up to date, but nothing is at present going through the press.

The total number of observations made with the transit circle during the year is

Level determinations	209
Azimuth	247
Collimation	40
Nadir	177
Observations of R.A. (zone stars)	5168
„ N.P.D. (zone stars)	5214
„ R.A. (clock stars)	967
„ N.P.D. (clock stars)	57

Time Service.—This worked satisfactorily during the year. In addition to the time ball at Fremantle a time gun has been established both there and in Perth.

Meteorological.—The usual routine has been continued, and the forecasts have again been very successful. The annual

report for 1901 is printed and will shortly be distributed. The Milne seismograph has worked satisfactorily throughout the year, and abstracts of the records have been forwarded to Professor Milne.

Lovedale Observatory, Cape Colony. (*Dr. A. W. Roberts's.*)

The work of this observatory has been, as in previous years, the observation of variable stars south of declination −30°.

Owing to the unfavourable weather during 1902, the observations made were not so numerous as in the previous year.

The following is a summary of work done :

	Stars.	Observations.
Algol variables	5	503
Rapid variables	1	21
Short-period variables	22	369
Long-period variables	68	2696
Suspected variables	10	90
Total	106	3679

The observations of Algol variables were taken for the most part with the prismatic equatorial recently constructed by Cooke, and the other observations either with the 1-inch or the 3-inch telescope.

The mode of observation is that followed in previous years. With both the 1-inch and 3-inch telescopes, two eye-pieces, one giving a direct and the other a reverse position of the field, are used.

In the case of the prismatic telescope, each observation is the mean of four or six pointings, the field being situated through 90° or 60° respectively. As a result of this system of observing, very accordant light curves of the southern Algol stars have been secured.

Mr. Tebbutt's Observatory, The Peninsula, Windsor, N.S. Wales.

The work done at this observatory during 1902 is quite equal to that of the year preceding. It is classified as follows :

Meridian Department.—

Nights on which the time was determined		103
Transits of stars with a declination not exceeding 40°		422
Transits of stars of high declination for azimuth		91
Separate determinations of	level error	277
	collimation error	29
	azimuth error	68

Like its predecessor, the year 1902 was a very dry one, being, as regards rainfall, the driest recorded at the observatory for forty years. The level disturbances were therefore not so great as usual.

Extra-meridian Department.—The following micrometer comparisons were made with the equatorials:

Objects Compared.	Nights of Observation.	Number of Comparisons.	Number of Comparison Stars.
(2) Pallas...	... 11	134	5
(4) Vesta	... 13	124	6
(8) Flora	... 17	176	10
(42) Isis	... 25	270	16
(164) Eva...	... 7	65	7
Comet *b* 1902 (Perrine) ...	... 7	51	10

Comet *b* 1902, was still under observation at the close of the year, and will probably be followed till it again becomes visible in northern latitudes. Double-star observations were made on eighty-two different dates, and the number of pairs measured is fifty-four of the most interesting objects selected from Innes' Reference Catalogue. The work involved 1765 settings for position-angle and 1503 double settings for distance. A long series of measures of *α Centauri* was sent to Dr. A. W. Roberts, of South Africa, in accordance with his request. In addition to the work already mentioned, a few observations were made of lunar occultations of stars and of phenomena of *Jupiter's* satellites. The usual rainfall and maximum and minimum temperature observations have also been carried on throughout the year.

Notes on some Points connected with the Progress of Astronomy during the Past Year.

Discovery of Minor Planets in 1902.

Fifty new planets were discovered during the past year, as follows :

Provisional Designation.	Permanent Number.	Name.	Date of Discovery, 1902.	Discoverer.	Place of Discovery.
HP	481	...	Feb. 12	Carnera	Heidelberg
HR	...	...	Mar. 3	Wolf	,,
HT	482	...	,, 3	,,	,,
HU	483	...	,, 4	,,	,,
HW	...	...	,, 6	,,	,,
HX	484	...	May 7	,,	,,
HY	...	...	,, 7	,,	,,
HZ	485	...	,, 7	Carnera	,,
JA	...	...	,, 7	,,	,,
JB	486	...	,, 7	,,	,,
JC	...	...	,, ,,	,,	,,
JD	...	...	,, 11	,,	,,
JF	...	...	(1899 June 9)	Pulfrich	,,
JG	...	...	1902 June 26	Wolf	,,
JL	487	Venetia	July 9	Carnera	,,
JM	...	...	Sept. 2	,,	,,
JO	...	...	,, 3	Wolf	,,
JP	...	...	,, 3	,,	,,
JQ	...	...	,, 3	,,	,,
JR	...	...	,, 3	,,	,,
JS	...	...	,, 7	,,	,,
JT	...	...	,, 26	Carnera	,,
JV	...	...	Oct. 7	Wolf	,,
JW	...	...	,, 7	,,	,,
JX	...	...	,, 7	,,	,,
JY	...	...	,, 24	,,	,,

Provisional Designation.	Permanent Number.	Name.	Date of Discovery, 1902.	Discoverer.	Place of Discovery.
JZ	...	...	Oct. 24	Wolf	Heidelberg
KA	...	...	,, 25	Dugan	,,
KB	...	...	,, 25	Wolf	,,
KC	...	...	,, 25	,,	,,
KD	...	...	,, 25	,,	,,
KF	...	...	,, 25	,,	,,
KG	...	...	,, 25	,,	,,
KH	...	...	,, 25	,,	,,
KJ	...	...	Nov. 4	Dugan	,,
KL	...	...	Oct. 25	Wolf	,,
KM	...	...	Nov. 20	,,	,,
KN	...	...	,, 20	,,	,,
KO	...	...	,, 21	,,	,,
KP	...	...	,, 21	,,	,,
KQ	...	...	,, 21	,,	,,
KR	...	...	,, 21	,,	,,
KS	...	...	,, 21	,,	,,
KT	...	...	,, 21	,,	,,
KU	...	...	Dec. 2	Charlois	Nice
KV	...	...	,, 23	Wolf	Heidelberg
KW	...	...	,, 24	,,	,,
KX	...	...	,, 24	,,	,,
KY	...	...	,, 24	,,	,,
KZ	...	...	,, 24	,,	,,

The number of discoveries is far the largest on record in any year, but it is possible that some of the recent discoveries may prove to be planets already known. The planets provisionally designated by the following letters proved to be identical with known planets :—HL with 358 *Apollonia*, HO with 458, HQ with 93 *Minerva*, HS with 359 *Georgia*, HV with 72 *Feronia*, JH with 486, JJ with 451 *Patientia*, JK (probably) with 470 *Kilia*, JN with 311 *Claudia*, JU with 106 *Dione*, KE with 19 *Fortuna*, KK with GT, each being probably identical with (156) *Xanthippe*.

Planet GL, unnumbered at the date of the last Report, has since received the permanent number 480.

The following planets do not receive permanent numbers, not having been sufficiently observed :—HM, HR, HW, HY, JA, JC, JD, JF, JG, JM. The discovery of JE was cancelled as erroneous.

The discovery of JF is a triumph for the stereo-comparator, Dr. Pulfrich having detected the planet by its aid on a plate

taken three years earlier, on which the trail had escaped detection

The following planets have been named : –359 *Georgia*, 472 *Roma*, 475 *Ocllo*, 477 *Italia*, 478 *Tergeste*.

The interesting planet *Ocllo*, whose orbit is the most eccentric of the whole family, has been recovered at the present opposition, being of the fourteenth magnitude.

Several observations of *Eros* were obtained in Europe and America a few months ago ; during its opposition it is in such high south declination that it is out of reach of northern observers.

A. C. D. C.

The Comets of 1902.

The comet history of the year is practically limited to the observations of four comets.

Comet 1902 *a* was discovered by Mr. Brooks, of Geneva, New York, on April 14. Situated in the constellation *Pegasus*, observations were possible only in the morning sky, and the rapidity with which the comet approached the Sun considerably curtailed these. It is to be feared that the comet was insufficiently observed, and that the true form of the orbit will remain doubtful. The earlier course of the comet, prior to discovery, had been through *Cygnus*, where the opportunities for detecting it, if more favourable in position, were discounted by the greater faintness of the object. This comet is reported to have had a tail some twenty minutes long, and in a photograph of comparatively short exposure taken by Dr. Max Wolf this tail is shown as a fan-like appendage with the southern concave border noticeably brighter than the northern. There is scarcely any recognisable nucleus, but the object is very feebly impressed on the photographic plate.

The second comet (1902 *b*) was discovered by Mr. Perrine, of the Lick Observatory, on August 31, and independently by M. Borrelly at Marseilles, a night or two later. It was described by Mr. Perrine as a slightly elongated nebulosity, four minutes in diameter, with a well defined nucleus and some evidence of a tail. This object, found in *Perseus* and travelling northwards, was easily followed, and its continually increasing brilliancy attracted general attention. A rapid movement to the south in October carried it into the southern hemisphere, where it has since been observed by Mr. Tebbutt and others. It is not impossible that the comet will be seen again in these latitudes in February or March, when it will pass through *Canis Major*, and should have a brilliancy approximately equal to that of the time of discovery. The observations are well represented by a parabola, but an interesting feature in the orbit is the near approach it makes to that of *Mercury*. The comet was separated from the planet, when nearest, by about 0·02 R, a close approach, but scarcely sufficient to disturb noticeably the parabolic velocity.

Numerous observations have been made of the physical appearance of the comet, and many photographs have been taken. For the general results of this kind of observation it will be sufficient to refer to the illustrated paper communicated by the Astronomer Royal to the November number of the *Monthly Notices*, in which number is also given an account by Dr. Max Wolf of an attempt to obtain a stereoscopic effect by exposing plates at slightly different times.

The third comet, known as *c*, was discovered previous to that of Perrine, and passed its perihelion some months earlier ; but, owing to an unfortunate circumstance, intelligence of the discovery did not reach Europe till September. On July 22, Mr. Grigg, of Thames, New Zealand, suspected a comet in the constellation *Leo*. Examination on subsequent evenings confirmed this suspicion, and he gave notice to Mr. Baracchi and others. Mr. Baracchi did not receive information till August 6, and made careful search over a wide area at the earliest possible opportunity, but without success. He therefore awaited confirmation or fresh information from some other source ; but unfortunately the comet was seen only by Mr. Grigg. The observations are rough, but Mr. Grigg has computed a set of elements from his data, which show that the comet when at its brightest must have passed through *Taurus* and *Gemini* in the preceding June. In these constellations it was scarcely likely that the comet would have been seen in northern latitudes. It was decreasing in brilliancy when seen by Mr. Grigg at the end of July, and under the adverse circumstance of doubtful position and fading illumination it was scarcely likely that it would be recovered when intelligence reached this country.

The last comet discovery of the year was made by M. Giacobini, of Nice, to whom we have been indebted for the detection of several faint comets. This one is also a faint object, but is particularly interesting on account of its great perihelion distance (2·8 R). With the single exception of the comet of 1729 there is no instance of a comet remaining at so great distance from the Sun. Necessarily the motion is slow, and any variation in brilliancy scarcely perceptible. It will not reach its perihelion till next March, and observations will be possible for some time to come. An accurate ephemeris has been prepared by Dr. Ristenpart, especially adapted to a plan which he has suggested as desirable for the reduction of extra-meridional observations of comets. Since the suggestion offers some advantages, and is likely to be gradually adopted, too wide a publicity cannot be given to the proposed innovation, in order to avoid subsequent confusion in the definitive determination of orbits.

Some other comets have passed through perihelion without being seen. Among these may be mentioned Swift's comet of 1895, and another known as Tempel-Swift. The former of these was probably in perihelion in November, and observations might have been made in the summer. But the conditions for

observing were not so favourable as in 1895, and the extreme faintness of the comet has baffled the search. The second is the comet discovered by Tempel in 1869, and re-discovered by Swift in 1880. It was seen in 1891 by Barnard. An ephemeris for this apparition was prepared by M. Bossert, but apparently without success. August seemed a fairly favourable time to recover it, and in this month Dr. Max Wolf applied the photographic method to secure its detection. Up to the present it has not been seen.

Mr. Lindemann's offer to subsidise inquiries in the matter of comet orbits whose definitive elements have not been determined has been effective, and several sets of elements of ancient comets have been added to our catalogues, mainly through his generosity.

Progress of Meteoric Astronomy in 1902.

January Meteors.—On January 2, during intermittent watches amounting to two hours, Mr. T. W. Backhouse, at Sunderland, observed 24 meteors, including 18 *Quadrantids*. On the following night, in $1\frac{3}{4}$ hour, 10 meteors, including 5 *Quadrantids*, were seen. On January 2, $9^h\ 52^m$ to $10^h\ 37^m$, Mr. J. H. Bridger, at Farnborough, counted 6 meteors (3 from *Quadrans*).

April Meteors.—The *Lyrids* appear to have escaped observation, the moon being full on April 22.

July Meteors.—Mr. R. M. Dole, Ogunquit, Me., U.S.A., watched for the *Aquarids* on July 30, 8^h to $14^h\ 45^m$ and found the shower in rather strong evidence, 62 of its meteors being counted in the $6\frac{3}{4}$ hours over which observations extended. Between 12^h and $14^h\ 45^m$ the rate of apparition was 1 every $3\frac{1}{3}$ minutes. The meteors were mostly slow and faint, with long paths.

August Meteors.—There was little interference from moonlight, but cloudy weather was very prevalent over the west of England, though the sky seems to have been generally favourable in the eastern counties. At the Royal Observatory, Greenwich, the following results were obtained :

Date.	Time of Watch.	Duration.	Observers.	No. of Meteors.	No. of Perseids.
	h h				
August 9	10 to 15	5	3	28	22
10	9 „ 16	7	3	106	94
11	$9\frac{1}{2}$ „ $13\frac{1}{2}$	4	3	74	67
12	9 „ 16	7	3	101	92
13	10 „ 12	2	1	23	21
Totals, five nights		25	...	332	296

Mr. G. M. Knight, London, watched the sky on seven nights

between July 31 and August 10, and counted 539 meteors. Of these 239 were observed on August 10 in $3\frac{3}{4}$ hours.

Mr. A. King, Leicester, obtained observations between July 27 and August 12, and during watches extending over $11\frac{1}{2}$ hours recorded 98 meteors (32 *Perseids*). "The maximum seemed to occur on August 11 or 12, probably the latter night."

Mr. Backhouse, Sunderland, saw 33 *Perseids* in about $1\frac{1}{4}$ hour on August 11, between 11^h and 13^h 50^m.

At Bristol, owing to unusually inclement weather, the writer could only secure brief observations on five nights between August 2 and 14, when 53 meteors were seen in about 4 hours' watching.

Mr. C. P. Olivier, University of Virginia, U.S.A., watched on August 10, between 12^h 33^m and 16^h 8^m, and counted 70 meteors (42 *Perseids*). On August 11, between 13^h 38^m and 16^h 8^m, there were 102 meteors (76 *Perseids*). Rate of *Perseids*, August 10, 1 in 5 minutes; August 11, 1 in 1·9 minute.

Mr. Dole, Ogunquit, Me., describes the *Perseid* display as "very active" in 1902, with maximum on August 12, 14^h 30^m. He recorded the following numbers:

	h m	h m	
August 12	11 20 to	15 21	261 *Perseids*
„ 13	11 40 „	15 18	176 „

Reports have been received from a considerable number of other stations, and they prove that the *Perseid* shower was a fairly rich one—probably stronger than the average—that the maximum occurred on the morning of August 13, and that the centre of radiation exhibited its normal displacement to the E.N.E., as observed on successive nights. The following are some determinations of the radiant position:

Date. 1902.	Radiant. α °	δ °	Meteors.	
August 1–3	37	+55	26	G. M. Knight
3	$40\frac{1}{2}$	+54	6	C. L. Brook.
4–5	40	$+55\frac{1}{2}$	12	G. M. Knight.
8	$42\frac{1}{2}$	$+54\frac{1}{2}$	11	H. J. Townshend.
8–10	44	+53	7	C. L. Brook.
9	38	$+56\frac{1}{2}$	....	Herr Koss.
10	39·5	$+56\frac{3}{4}$	42	C. P. Olivier.
10	44	+58	9	A. King.
10	$44\frac{1}{2}$	+57	43	G. M. Knight.
10	45	$+58\frac{1}{2}$	15	W. F. D.
10	$45\frac{1}{2}$	$+54\frac{1}{2}$	...	Herr Koss.
11	$46\frac{3}{4}$	$+56\frac{3}{4}$	76	C. P. Olivier.
12	47	$+58\frac{1}{2}$	9	W. F. D.
48	48	$+56\frac{1}{2}$	6	A. King.

Professor J. Lycova, of the Jourieu Observatory, Dorpat, photographed 7 meteor trails on 1901 August 11, of which 5 were *Perseids*, indicating the radiant at α 43° 55′·8, δ +57° 10′·3. On August 12 he found the radiant evidently slightly east of that position.

Meteoric Showers in September.—During the first week of the month 116 meteors were seen at Bristol during 18 hours of observation. Two pretty conspicuous showers of *Polarids* were seen, and there were active displays of η *Aurigids* and β *Triangulids*.

October Meteors.—Cloudy weather and the light of a full Moon appear to have effaced the *Orionid* shower.

November Meteors.—Though the *Leonids* of the three years 1898, 1899, and 1900 disappointed every eye, the hope was encouraged that, as the shower had exhibited a decided intensification in 1901, there would be a pretty strong recurrence of it in 1902. Moreover the latter year was suggested as favourable to its return, owing to the fact that brilliant displays had been witnessed in 902, 1002, 1202, and 1602, and that exactly three revolutions of the swarm were performed in a century. The meteors were therefore looked for in 1902 November with almost equal enthusiasm to that shown in previous years, though the Moon most inopportunely became full at the very time when the maximum was expected. Other conditions proved unfavourable; overcast skies just at the important period appear to have veiled the meteors from the majority of observers both in England and America. At stations, however, where suitable views could be obtained there was no sign of an abundant display; only a few *Leonids* could be seen interspersed with the ordinary "sporadic" shooting stars. Reports from sixty stations in America affirm that practically no shower of *Leonids* was seen. Before sunrise on the morning of November 13 the *Leonid* radiant seemed quiescent or nearly so, as observed at Bristol and by Mr. A. King at Leicester. Cloudy nights then intervened, but on November 18, between 2 and 3 A.M., some 8 or 10 meteors were seen by Mr. J. R. Henry, of Dublin, "flashing from *Leo*," but their identity as true *Leonids* is somewhat questionable, though the date is certainly not too late for belated members of the stream. On November 14, from midnight to $15^h\ 30^m$ E.S.T., Mr. Wendell and assistants at Cambridge, Mass., watched a sky partly involved in cloud and haze and only counted 5 meteors. At Mexico City, Mexico, Mr. L. G. Léon maintained a look-out on November 14, 2 to 4 A.M., and states that in the beautifully clear, moonlit sky he recorded 18 *Leonids*. It is obvious, however, from the chart of tracks published in *Popular Astronomy* (1903 January) that very few of these meteors were genuine *Leonids*. It is often difficult—sometimes impossible—to identify the latter objects from the meteors of contemporary showers directed from radiants near the Sickle of *Leo*.

Of the *Andromedids* (November 23) and *Geminids* (Decem-

ber 10–12) little or nothing appears to have been observed in 1902. The year generally was unfavourable for meteoric observation, owing to the unusual amount of cloud that prevailed and to the fact that bright moonlight virtually overpowered several of the principal showers.

The following is a list of real paths of bright meteors observed in England during the past year :

Date. 1902.	G.M.T. h m	Brightness.	Height at First. Miles.	Height at End. Miles.	Length of Path. Miles.	Velocity per Sec. Miles.	Radiant Point. α ° δ °	Observers.
May 27	12 22	$1\frac{1}{2}-$ ♀	63	39	120	24	282 − 24	2
July 13	10 30	= ☽	89	51	51	26	315 + 31	60
27	11 36	4	71	52	45	33	351 + 3	2
Aug. 21	14 2	= ☽	65	33	611	15	283 − $10\frac{1}{2}$	20
Sept. 25	7 34	> ♀	88	57	34	> 100	254 + 46	2
Oct. 15	7 47	♀	62	54	130	37	150 + 43	3
Dec 2	7 20	> ♀	63	42	31	14	43 + 22	2

A fine meteor was seen by Professor A. S. Herschel, Captain P. B. Molesworth, and other observers on July 15, $9^h\ 32^m$. The former determined its radiant at 236°–13°, height 60 to 38 miles, observed path 51 miles, and velocity 17 miles per second.

Comparatively few new determinations of radiants have been obtained during the year. While watching the *Perseids* on August 10 Mr. Knight recorded 15 *β Andromedids* from a centre at $19° + 29\frac{1}{2}°$. The following radiants were the principal ones derived from observations at Bristol, July to September. In some cases a few meteors recorded in previous years were combined with those seen in 1902, in order to strengthen the positions and ascertain them more accurately :

Years.	Date.	Radiant. α ° δ °	Meteors.	Notes.
1885–1902	July 5–13	22 + 22	7	Swift, streaks.
1877–1902	July 7–9	10 + $45\frac{1}{2}$	6	Swift, streaks. Very early Perseids.
1885–1902	July 9–21	30 + 36	7	Swift, streaks.
1902	Aug. 24–Sept. 7	74 + 41	7	Swift, streaks.
1885–1902	Aug. 25–Sept. 16	353 − 11	15	Slow, long paths.
1902	Aug. 26–Sept. 7	337 + $81\frac{1}{2}$	10	Swift.
1902	Sept. 3–7	118 + $83\frac{1}{2}$	8	Swift.
1902	Sept. 3–7	30 + 37	8	Swift, short.
1877	Sept. 7–25	100 + 13	10	Swift, streaks.
1900–1902	Sept. 29–Oct. 2	347 + 3	13	Very slow.

Detonating Fireball observed in Sunshine.—At $10^h\ 55^m$ G.M.T. on the morning of April 10, when the Sun was shining and the

air still, strange sounds of a very loud and unusual character were heard over East Tyrone, Ireland, by many persons, who were much alarmed and considered them the accompaniment of an earthquake. The Rev. E. F. Campbell says : "The sound seemed to be very deep in the heavens ; to the east it appeared to be far above thunder distance and about half as loud. It lasted from thirty to sixty seconds, and I can only describe it as being like the whirring of a very large motor with a deep tone." Another observer at Market Hill, Co. Armagh, describes it as "a great rumbling sound which lasted about eight seconds. It was a full round booming pervaded by a regular wavy rumbling. A boy eleven years of age, working in a garden, when he heard the noise ran away and said the ground was shaking." At about the same time (probably a few minutes previously) a pear-shaped fireball with a tail was seen by Mrs. Martin, of Dunsink, Co. Dublin, passing overhead and falling low towards the north horizon. A singular feature of the event is that a rushing noise above her head attracted Mrs. Martin's attention to the meteor, and that this sound continued to be distinctly heard during the three or four seconds occupied in the descent of the object. It was also seen by Master R. Fitzmaurice, of Carlow, and he says it flashed into sight in the N.E. and left a long train behind. The radiant point of the meteor was probably in *Aquarius* or *Pisces* in the southern sky, and the disruption of the object must have occurred comparatively near the Earth's surface in the district of Dungannon and Lough Neagh, though none of the fragments appear to have been found.

Observed Fall of a Meteorite.—The most important meteoric event of the year occurred on September 13, $10^h\ 55^m$ G.M.T., when a meteorite fell at Crosshill, near Crumlin, and about twelve miles west of Belfast, Ireland. The stone has been acquired for the British Museum, and the explanatory label * attached to the case containing it gives all the essential particulars of the event in a concise form :

"On Saturday, September 13, at 10.30 A.M.,† a loud noise as of explosions was heard at various places on the western side of Belfast ; among others, Antrim, Crumlin, Lisburn, Moira, Lurgan, and Pointzpass. Of these Antrim and Pointzpass are thirty miles apart. One observer at Crosshill at first thought that the noise was due to the bursting of the boiler in the mill at Crumlin a mile away ; another thought that a train had run off the line. Two or three distinct detonations were heard. The detonations were followed by another sound likened to that made by escaping steam ; other observers describe it as a rattling noise, similar to that made by a reaping machine, but much louder. Two men, Walker and Montgomery, were at the time stacking

* Written by Mr. L. Fletcher, F.R.S. A very interesting and illustrated description by the same author appeared in *Nature*, 1902 October 9.

† Local time.

hay at Crosshill. The former was on the top of the nearly finished stack, and immediately after hearing the noise saw from this lofty point of view something whirl into the adjacent corn field.* The exact spot was indicated by a cloud of dust which at once rose above the standing corn. It was only twenty yards distant from a tree on which a third man, Adams, was at work gathering apples. It was found that a deep hole had been made in the soil. Adams went for a spade, and within a quarter of an hour of the fall extracted from the hole a black, dense stone, which had penetrated to a depth of eighteen inches and had then been stopped by a much larger stone lying in the soil The black stone was hot when extracted, and is said to have been warm even an hour later. Before being cut to show its interior the stone weighed 9 lbs. $5\frac{1}{2}$ oz., and was $7\frac{1}{2}$ inches long, $6\frac{1}{2}$ inches wide, and $3\frac{1}{2}$ inches thick. The stone consists of a grey material covered with a thin black crust. Such a crust is always found on meteoric stones. The surface of the meteorite, owing to the immense compression of the air in front of the swiftly moving body, becomes hot enough to be luminous, and is well scorched. The pressure of the air on the front of the meteorite continues to increase until at last the material yields and breaks up with violent detonation. If the fragments thus produced are still travelling with great speed the new surfaces likewise become encrusted, though not as much as the earlier ones. The form of the Crumlin stone is distinctly fragmental, and one large surface of fracture well illustrates this stage of later scorching. The meteorite chiefly consists of stony material, probably a mixture of olivine and enstatite ; through it are dispersed grains of a metallic alloy of iron and nickel. Here and there are small nodules of the bronze-coloured mineral troilite, a compound of iron and sulphur not found as a native terrestrial product."

The stone has not yet been submitted to chemical analysis.

Previous and most recent falls of meteorites occurred in the United Kingdom as follows :—

1881 March 14. Stone $3\frac{1}{2}$ lbs. in weight fell on a railway siding near Middlesborough, Yorks.

1876 April 20. Mass of iron $7\frac{3}{4}$ lbs. in weight fell at Rowton, near Wellington, Shropshire (*Monthly Notices*, xxxvi. pp. 205–6).

Great Meteorite of Sinaloa, Mexico.—The *American Geologist* for 1902 October contains a paper by H. A. Ward, of Rochester, N.Y., descriptive of the above object. He visited Bacubirito, an old mining town in the Rio Sinaloa, in lat. 26° N. and long. 107° W., and the great meteorite was located about seven miles south of that place on a farm named Ranchito. Its appearance was that of a long monstrous boulder of black iron, which

* The meteorite fell on the farm of Mr. Andrew Walker, and he states that it must have descended perpendicularly, or nearly so, according to the shape of the hole, and the corn standing round was not beaten down in any way.

seems to be still burrowing to hide itself from the upper world. The earth was removed from round the meteorite, and its dimensions were then ascertained to be : length, 13 ft. 1 in ; width, 6 ft. 2 in ; thickness, 5 ft. 4 in. Mr. Ward concluded that this object is probably the largest of its kind in existence, and estimated its weight as approximately fifty tons. The application of acid brought out the Widmanstatten figures in a beautiful manner. Professor J. E. Whitfield made an analysis of the meteor as follows :

Specific gravity ... ... 7·69			
Iron... ...	88·944	Sulphur ...	0·005
Nickel ...	6·979	Phosphorus ...	0·154
Cobalt ...	0·211	Silicon ...	trace

New Determinations of Radiants.—Professor D. Eginitis, of Athens, gives a list of radiants in *Astronomische Nachrichten*, 3815, two of which are probably new. He mentions that in 1900 and 1901 the maximum of the *Perseids* occurred on August 11. M. Eginitis specially remarks upon the fact that the principal showers apparently exhibit multiple radiants. It will be remembered that Mr. J. W. C. Herschel attributed a similar character to the *Lyrid* shower of 1901 (*Monthly Notices*, lix. p. 564). In fact, all regular meteoric observers have met with instances of compound radiation. This feature obviously requires further investigation, but it may well be regarded as a necessary outcome of the materials employed. Observational inaccuracies, erratic flights of perturbed meteors, and mistakes in apportioning meteors to their various radiants, must sometimes induce indefinite radiation, and the path intersections will indicate a number of contiguous foci. But careful observations of the same showers in several years will prove that the latter are not due to concentric meteor streams, but are rather an effect of the accidental grouping of positions depending upon uncertain data.

Meteoric Section of the British Astronomical Association.—Eleven annual reports have been published (the last in 1902 April), and they contain a mass of useful information in the form of tables and descriptive matter, illustrative of and resulting from meteoric work since 1890. The twelfth report is on the eve of publication by the present director, Mr. W. E. Besley.

W. F. D.

Solar Activity in 1902.

Although the solar activity in 1902, as evidenced by the numbers and areas of Sun-spots, has not been great, there can be no doubt that the actual minimum is past, and that a new cycle has distinctly begun. This is clearly seen in the diminution of days without spots, the 81 per cent. of 1901 having fallen to

about 72 per cent. in 1902. The percentage numbers of spotless days from the Greenwich records for 1898, 1899, and 1900 were 13·5, 33·8, and 53·1 respectively; so that, in spite of this improvement, 1902 must still rank as an exceedingly quiet year. The mean daily spotted area has increased markedly over that for 1901, being very nearly double; between 50 and 60 millionths of the Sun's visible disk as compared with 29 for 1901, but falling much short of the 75 registered in 1900. The number of separate groups has increased in an even larger proportion than the mean area, being 37 as against the 15 of 1901. The principal groups of the earlier part of the year were three in number. The first of these ran its course from January 5 to January 15, and was a group of the type which increases in actual as well as in apparent size the more fully it is presented towards the Earth. The second, seen from March 3 to March 14, was the largest group of the year. The third, from May 24 to June 4, was much smaller. The intervals between these times of disturbance were very quiet; from March 15 to May 4 inclusive, a period of 51 days, no spots were observed, and from June 5 to September 17 it was only occasionally that spots were seen, and these were always very small, faint, and short-lived. But the appearance of a new group on September 18 marked the commencement of a more regularly active period, more than half the groups of the year appearing on or after that date; and though these later groups never equalled that of March 3–14 in size, there has been scarcely a day from September 18 to the date of this report when the sun has been wholly free both from spots and from faculæ.

The faculæ in 1902 have shown a much more unmistakable increase than the spots. Their mean daily area had fallen from 337 in 1899, and from 180 in 1900, to 29 in 1901, but in 1902 it reached practically the same level as in 1900. M. Guillaume, from the observations made at the Lyon Observatory, indeed puts the total faculous area higher than in 1900; viz. 97·5 thousandths of the visible hemisphere in 1902 as against 81·2 in 1900; whilst the number of distinct groups was 363 in 1902 as compared with 210 in 1901, and 134 in 1900.

The distribution of spots in heliographic latitude has also been characteristic of the beginning of a new cycle. Most of the groups have formed between the 20th and 30th parallels; one group very nearly on the 40th. But three or four groups have been seen much nearer the equator; notably the first group of the year, that of January 5 to 15, which had its centre in S. latitude 8°.

The distribution of the faculæ in latitude has not altered much since the preceding year. M. Guillaume's figures show that there was a remarkable change from 1900 to 1901; only 20 per cent. of the groups having a higher latitude than 40° in the former year, whilst more than 40 per cent. exceeded that latitude in the later. This proportion was almost exactly preserved in 1902.

Of the two hemispheres the northern was much the more active in 1902, so far as sun-spot area is concerned; M. Guillaume's figures showing almost exactly double the area for the north as for the south; 1177 millionths, as against 594. The faculæ were more equally divided; out of 363 groups, 189 appearing north of the equator, and 174 south of it.

Looking back over the cycle just past, it would seem to have been decidedly above the average in length, the middle of the depression with which it began falling about 1889·3, and the middle of that with which it terminated about 1901·8, so that its entire duration was 12·5 years. The period of increase was about 4·3 years and that of decrease 8·2 years, the maximum falling about 1893·6. E. W. M.

The Prominences.—A slight reduction in the mean daily number for the southern hemisphere is shown by the observations made at Kenley during 1902 compared with the previous year.

The figures derived from ninety days of observation in 1901 and eighty-nine days in 1902, are as follows :—

	1901, Per Diem.	1902, Per Diem.
North hemisphere	2·56	2·69
South ,, ...	3·06	2·69
Total mean number	5·62	5·38

The two hemispheres would thus appear to have been reduced to exact equality as regards numbers produced; the southern prominences, however, have exceeded the northern in size, being on the average 6 per cent. larger.

The distribution in latitude has closely followed that in the previous year; thus in each hemisphere there is shown a strongly marked zone of activity, situated roughly between the parallels of 50° and 60°, and two less well-defined and far less active zones in lower latitudes. The limits of the zones of maximum activity are indicated at about 65° north and south, or 5° nearer the poles than was the case in 1901.

A few small and transient eruptions have occasionally been seen in the otherwise barren polar regions.

Speaking generally, the year appears to have been an extremely quiet one. No large eruptive prominences have been recorded, and only one metallic prominence. This was on January 19, in south latitude 30°, and, as so frequently happens, the reversals of the magnesium lines could be traced near the same position in the chromosphere after an entire rotation, viz. on February 15. J. E.

Determination of the Solar Motion.

The last reports of the Council referring to the progress made towards the determination of the direction of motion and velocity of the solar system were in 1891 and 1892, when attention was called to the following researches :

Dr. Stumpe, *Astron. Nach.*, Bd. 156, No. 3000.
Prof. Boss, *Astron. Jour.*, Nos. 195 and 196.
Prof. Porter, *Trans. Obs. Cincinnati*, No. 12.
Prof. Vogel and Dr. Kempf, *Astr Nach.*, Bd. 132, No. 3150.

During the ten years which have elapsed since these reports a good deal of attention has been given to this subject, both on the theoretical and the practical side. The methods employed have been criticised and elucidated, the available material has been increased by the determination of new proper motions of stars, and the old material has been improved by the more accurate determination of the systematic errors of the catalogues used in the determination of proper motions. In addition the linear velocity of the solar system has been obtained with greatly increased accuracy by new determinations of velocities of stars in the line of sight. Among the many astronomers who have touched on these questions during the last decade the names of Boss, Campbell, Kapteyn, Kobold, Newcomb, Porter, Ristenpart, and L. Struve are specially prominent.

The three best known methods of finding the solar motion are those of Airy, Argelander, and Bessel, to which was added, in 1900, another by Prof. Kapteyn.

(*a*) Airy's method is the most direct and the most simple in practice. The observed proper motions of each star furnish two equations of condition for the parallactic motion of the Sun resolved in three directions at right angles. Each equation involves errors due to observation and also the *motus peculiaris* of the star. If the distances of the stars were known these equations might be solved on two suppositions : (i.) that the irregularities were all due to errors of observation, or (ii.) to the *motus peculiares* of the stars, and the weights adopted in forming the normal equations would be different. As, however, the distances are not known, the equations are solved as they would be were all the stars at the same distance from the Sun.

The other methods adopted all aim at eliminating these unknown distances.

(*b*) In Argelander's method the direction of the solar apex indicated by the stars in a small area of the sky is considered to be the mean of the directions indicated by the individual stars, so that each star thus furnishes one equation.

(*c*) In Kapteyn's method the direction of the solar apex indicated by the motions of the stars in any small area of the

sky is considered to be that which makes the sum of the resolved velocities in a perpendicular direction zero.

(*d*) Bessel's method consists in determining the poles of the directions of the proper motions of the stars, which would, if the solar motion were the only cause of these proper motions, lie on a great circle perpendicular to the direction of the solar motion. The circle is therefore drawn which best collects the various poles of the observed proper motions.

In the application of these methods different normal equations arise, as is shown by Prof. Kapteyn. He points out that the methods of Airy, Argelander, and Bessel will give better results when the equations of condition are formed from the means of all the stars grouped in small areas than when formed singly for each star. When this is done the results found by Airy's, Argelander's, and Kapteyn's methods will not differ much. He also does not consider it legitimate to group the stars according to their proper motions in the application of Airy's method as usually made, and attributes the regular change found by Stumpe in the declination of the apex when proper motions are grouped in this manner to an inherent defect in the method. In reply to criticism on his criticism of Airy's method, Prof. Kapteyn makes it clear that Airy's method applied to proper motions in *two* directions will lead to the same equations as his own method, and that his criticism of Airy's method is directed only against its separate application to right ascensions and declinations.

In this connection Prof. Boss may be quoted, who arrives at the conclusion that the great majority of the stars of the seventh magnitude or brighter will be included between relative distances 1·0 and 3·0, and under these circumstances the theoretical objections against the very convenient method proposed and illustrated by Airy practically disappear.

An approximate determination of the solar motion by a statistical method is given by Prof. Newcomb which illustrates the inherent difficulties of the problem in a forcible and extremely instructive manner. It is shown how widely the actual distribution of proper motions differs from the normal distribution of the law of errors, and it is pointed out that the best results are to be obtained by diminishing the weights of the more discordant motions. Prof. Newcomb exemplifies his method of rejecting the discordant observations in his discussion of the proper motions of the Bradley stars to give the precession and the solar apex. Out of 3181 stars he rejects 654, or a little more than one fifth.

Dr. Kobold's determinations are on a different footing from the others, as he has used Bessel's method. Applying this method to the proper motions of Auwers-Bradley, he found for the declination of the apex of the solar motion $D = -3°$, whereas Airy's and Kapteyn's methods give in different hands values ranging about $D = +30°$. Dr. Kobold obtained a similar result from 523 southern stars taken from Dr. Auwers' Funda-

mental Catalogue, and in a still later paper, in which he used proper motions of 1709 well-distributed stars, he obtained D = −0°·2, but obtains the more satisfactory result D = + 16°·5, when he takes the means for all the stars in the same part of the sky, and does not treat each star separately. The method is certainly open to the grave objection that a change of 180° in the direction of the motion of a star does not affect the result if each star is taken by itself, and it is not easy to separate the direct and retrograde motions. According to Mr. Everet Yowell (*A. J.*, No. 479), who applied Dr. Kobold's method, entirely different results were obtained, according as different approximate positions were assumed at the start. The method is also considered in a brief note by M. Radau (*Bulletin Astron.* tom. x. p. 401).

Dr. Ristenpart's determination of the solar motion forms part of a large paper in which the distribution of the stars in space and value of the precessional constant are also considered. The stars he uses for precession and solar motion are between the limits of 20° and 25° N. Dec., and the Berlin observations made about 1880 are compared with those of Bessel made at Königsberg about fifty years earlier. He uses Airy's method, and considers in his equations a possible rotation of the stars about an axis perpendicular to the plane of the Milky Way. He divides the stars into four classes and obtains results from each class.

Class.	Mean p.m.	Mean Mag.	No. of Stars.	M.	A.	D.
	″	m		″	°	°
I.	0·374	7·98	85	·279	286	31
II.	0·197	8·13	221	·109	275	44
III.	0·128	8·08	148	·961	255	23
IV.	...	...	4565	·027	267	20

where M is the parallactic motion of a star 90° from the apex, and A and D are the R.A. and Dec. of the apex.

Professor Newcomb by the use of Airy's method finds from the Bradley stars the following results :—

Stars of Small Proper Motion.

Mag.	No. of Stars.	M.	A.	D.
		″	°	°
1–2·9	64	·659	263·1	31·7
3–3·9	135	·561	262·7	26·8
4–4·9	327	·347	266·5	31·8
5–5·9	731	·314	268·5	32·0
6–6·9	1034	·281	277·4	30·6
7–	236	·286	278·2	33·6

Stars of Larger Proper Motion.

All mags.	644	″ 1·67	° 276·9	° 31·4

As a conclusion from his own and other work to 1899 he gives A = 18^h 30^m, D = + 35°, as the most probable position of the solar apex.

Professor Porter's new determination differs from his previous one in his adoption of systematic corrections to the catalogues from which he derived his proper motions, in the use of additional stars, and in the employment of Kapteyn's method. He finds

Class.	Proper Motion.	No. of Stars.	A	D.
			h m	°
I.	$''$ < 0·2	1037	18 45	54·1
II.	0·2–0·5	1063	18 37	39·6
III.	0·5–1·25	235	18 25	34·4
IV.	> 1·25	56	18 13	43·5

Professor Porter gives little weight to Classes III. and IV., and gives a double weight to Class I. on the ground that these stars are, judging from their mean proper motions, twice as distant as those of Class II., and therefore more widely scattered in space and less likely to be affected by any local drift. As a final result from 2000 stars he gives A = 18^h 42^m, D = 49°·3.

Professor Kapteyn included in the same paper a determination of the solar apex of the value of the precessional constant and the corrections required by the proper motions in declination of Auwers-Bradley. He uses 2640 stars, rejecting the *Hyades* and *Pleiades* groups and the stars observed in one coordinate only by Bradley. He also makes a determination from 699 stars of large proper motion taken from Professor Porter's catalogues, excluding the stars within 30° of the assumed position of the apex. He employs three different methods: (i.) statistical, (ii.) his own explained above, and (iii.) Airy's; and he also groups the stars in several different ways, according to the magnitude of the proper motion, the magnitude, and the spectral type. He obtains, for the precessional constant and the corrections to the proper motion of Auwers-Bradley, results in close agreement with Newcomb.

The results obtained by the several methods are in good agreement, the results being

	No.	A.	D.
		h m	
Bradley Stars ...	2640	18 8	+ 28 4
Porter's Stars ...	699	18 31	+ 32 7

He concludes for the most probable position

A = 18^h 14^m D = + 29°·5

Professor Boss' paper, "Tentative Researches upon Precession and Solar Motion," contains many valuable remarks on the general problem. He states as the result of his own studies that the best point of attack is offered by the stars brighter than

$7^{m}\cdot0$, after excluding stars having centennial proper motions greater than 10″, and perhaps also stars of magnitudes above the fourth. The determination of the parallactic motion which he gives in this paper is derived from a comparison of the Cape Catalogues for 1850 and 1880. Systematic corrections are applied to the right ascensions according to the conclusions of a paper by Professor Boss in *A. J.* No. 499. The number of stars employed is 3587, extending from the Equator to the South Pole. These are grouped into fifty-seven trapeziums, containing a number of stars varying from 10 to 223. Weights from one to six are assigned to the equations of condition arising from the separate trapezium, so as to allow for the accidental error, the probable amount of the residual systematic error, the effect of star drift, &c. Normal equations are formed separately for the right ascensions and declinations, Airy's method being employed.

The results obtained are :—

	M.	A.	D.
	″	°	°
From Right Ascensions ...	·043	269·3	42·7
„ Declinations	·039	251·4	48·5
„ both	·041	263·7	45·9

As Professor Boss states, the two weak points in this determination are : (i.) the short interval of time between the catalogues, (ii.) it relates only to one hemisphere. To overcome the second objection Professor Boss revises the determination made by Dr. L. Struve by applying corrections to make it agree with Newcomb's system of right ascensions and Boss' system of declinations, and obtains as a result $A = 267°\cdot0$, $D = 42°\cdot8$. The rest of the paper, as far as it relates to solar motion, is a *résumé* of other investigations, and the most probable position is given as

$$A = 18^{h}\ 20^{m} \qquad D = +\ 45°$$

Dr. L. Struve, in view of the differences found by Professor Newcomb and himself in the constant of precession, using the same material re-examined his previous work on the precession and solar motion. Some corrections depending on the right ascensions are applied to the declinations, differences are made in the weighting, and a number of stars excluded. The final result is, however, only slightly altered, being

$$A = 18^{h}\ 20^{m} \qquad D = +\ 23°\cdot5$$

The differences in the declination of the solar apex found by L. Struve, Newcomb, and Kapteyn and Boss from the proper motions of Auwers-Bradley are almost entirely caused by the systematic corrections applied to the declinations of Bradley. Struve applied nothing, Newcomb and Kapteyn a correction

which amounted to $-0''.8$ for stars near the Equator, and Boss one of $-1''.7$.

Professor Campbell's preliminary determination of the motion of the solar system is made from the extremely accurate values for the velocities in the line of sight obtained at the Lick Observatory. He has observed 280 stars, and deduces

$$V = -20 \text{ kilometres per sec.}$$
$$A = 18^h\ 30^m \quad D = +20°$$

The determination of the velocity by this method is much more accurate than one which can be deduced from the proper motions of stars whose parallaxes are known, and is a result which will only be improved by further spectroscopic observations. The agreement of the position of the apex with that deduced from proper motions seems extremely close, especially as there were no observations south of Dec. -30, and only few between $-15°$ and $-30°$. Professor Campbell finds for the average velocities of the stars in the line of sight a remarkable progression with their magnitudes.

No. of Stars.	Mag.	Average Velocity. km.
47	$>3^m.0$	13·05
112	$3^m.1$ to $4^m.0$	16·15
121	$<4^m.0$	19·44

Professor Campbell comes to the conclusion that the faint stars are moving faster than the bright ones, and remarks that this profoundly affects the question of methods of determining the structure of the sidereal universe.

The following are references to the papers referred to in the above report, though a number of shorter papers and notes are to be found, especially in the *Astronomische Nachrichten*.

Boss ... *Ast. Journal*, No. 501 (1901).

Campbell... *Astroph. Journal*, xiii. p. 80–9 (1901).

Kapteyn ... *Proc. Royal Acad. Sciences*, Amsterdam, vol. ii. p. 353 (1900), and vol. iv. p. 221 (1902). *Ast. Nach.* No. 3721 (1901), 3800 (1902). See also *Stein.* A. N. 3779.

Kobold ... "Nova Acta der Ksl. Leop. Carol.," *Deutschen Akademie der Naturforscher*, Bd. lx. 15, No. 5. Halle (1895). *Ast. Nach.* 3163, 3451, 3591, and others

Newcomb. "The Precessional Constant," *Astronomical Papers of the American Ephemeris*, vol. viii. Part I. (1897). *Ast. Journal*, No. 457 (1899).

Ristenpart. *Karlsruhe Observations* (1892).

L. Struve. *Ast. Nach.*, 3729 (1901), 3816 (1902).

F. W. D.

Investigations of Mr. E. T. Whittaker.

It has certainly been a welcome surprise to mathematicians to learn that the famous equation of Laplace admits of a general solution of quite a simple type. This has been shown by Mr. Whittaker in the *Monthly Notices*, vol. lxii. p. 617. He there proves the following theorem :—

"The general solution of Laplace's equation

$$\frac{\partial^2 V}{\partial x^2}+\frac{\partial^2 V}{\partial y^2}+\frac{\partial^2 V}{\partial z^2}=0$$

is $$V=\int_0^{2\pi} f(x\cos v+y\sin v+iz,\ v)\,dv,$$

where f is an arbitrary function of the two arguments $x\cos v+y\sin v+iz$ and v."

From this Mr. Whittaker has shown that the general solution of the differential equation of wave motions, namely,

$$\frac{\partial^2 V}{\partial x^2}+\frac{\partial^2 V}{\partial y^2}+\frac{\partial^2 V}{\partial z^2}=k^2\frac{\partial^2 V}{dt^2},$$

can be analysed into simple plane waves.

It is further proved that "distributions of simple waves exist such that, although each individual wave is periodic with respect to the time, yet the total disturbance at any point does not vary with the time." As for all such distributions the total disturbance can always be represented by a solution of Laplace's equation, we have the most interesting suggestion of an undulatory explanation of gravity. The conclusion of Mr. Whittaker's paper is as follows :—

"This undulatory theory of gravity would require that gravity should be propagated with a finite velocity, which, however, need not be the same as that of light, and may be enormously greater."

"Of course this investigation does not explain the *cause* of gravity ; all that is done is to show that the propagation across space of forces which vary as the inverse square of the distance does not require for its explanation any other property of the medium than one which has long been known and accepted."

R. S. B.

Nova Persei.

Interest in *Nova Persei* during the year has been mainly concentrated on the beautiful photographs obtained by Mr. Ritchey at the Yerkes Observatory, and by Mr. Perrine at the Lick Observatory. These photographs, which are given in the

Astrophysical Journal, show rings in which there are separate condensations which show large individual motions and in general not radial. The *Astrophysical Journal* and the *Astronomische Nachrichten* contain numerous papers as to the explanation of these phenomena, and, as a result, there seems to be a general consensus in favour of Kapteyn's explanation that finely divided matter having the observed structure is illuminated by light waves emanating from the Nova.

Several attempts have been made to determine the parallax of the Nova. The photographic determinations have resulted in a negative value of the order of $-0''\cdot10$. This is explained by Dr. Bergstrand as due to atmospheric dispersion, and with an allowance for this he obtains the result of $+0''\cdot033$. Dr. Chase, as the result of heliometer measures, has obtained the value $-0''\cdot02$, so that the parallax determinations may be said to confirm Dr. Max Wolf's parallax of $0''\cdot012$, derived on the assumption that the luminosity of the nebula was caused by a wave travelling with the velocity of light. Micrometric measures made by Professor Perrine and Professor Barnard agree with photographic results in showing that the proper motion of the Nova is extremely small. The Nova has diminished about three magnitudes during the year from $7^{m}\cdot0$ to $10^{m}\cdot0$. Isolated observations of the magnitude are to be found in the astronomical journals, but no general discussion has yet been published. A table has been published by Professor Pickering for converting the estimates of magnitude of the neighbouring stars given by Father Hagen to a photometric scale.

Professor Pickering has found a star of the thirteenth or fourteenth magnitude close to the present position of the Nova on a number of plates taken between 1890 October 26 and 1900 March 7, the differences of R.A. and Dec. as obtained from measures made on three of these plates being

$$\left.\begin{array}{lccc} \Delta\alpha & -1''\cdot6 & +1''\cdot2 & +0''\cdot2 \\ \Delta\delta & +1\cdot3 & -1\cdot0 & -1\cdot2 \end{array}\right\}$$

It seems probable that this is the coincident with the small star which M. Ceraski found on photographs before the outburst of the Nova. As Professor Barnard points out, now that *Nova Persei* is diminishing in brightness, it will soon be possible to see whether this faint star still exists in the neighbourhood. If not, then it is probable that the Nova is identical with this star. The star found by Professor Pickering was variable to the extent of half a magnitude, and it will be of interest to observe whether the Nova will descend again to the condition of a slightly variable star of between the thirteenth and fourteenth magnitudes. F. W. D.

Double Stars.

The arrangement of this report is that adopted for some years, the work being referred to under the heads, "Observation" and "Calculation." Abbreviated titles have been used as follows:

M. N.: Monthly Notices, R. A. S.
M. R. A. S.: Memoirs, R. A. S.
A. N.: Astronomische Nachrichten.
A. J.: Astronomical Journal.
A. S. P.: Astronomical Society of the Pacific.
L. O. B.: Lick Observatory Bulletin.
Obs.: The Observatory.
B. A. A.: Publications of the British Astronomical Association.

Observation.—Measures of some stars of special interest will be found:—

Sirius ...	R. G. Aitken, *A. S. P.* 84.
	W. Hussey, *A. S. P.* 84.
δ *Equulei* ...	R. G. Aitken, *A. S. P.* 87.
	W. Hussey, *A. S. P.* 87.
	W. W. Bryant, *M. N.* 1902 March.
	T. Lewis, *M. N.* 1902 March.
κ *Pegasi* ...	T. Lewis, *M. N.* 1902 March.
	W. Bryant, *M. N.* 1902 March.

New Double Stars—

W. J. Hussey. L. O. B. 21. Fifth Catalogue, 100 new doubles, 60 of which are under 1″·0 separation.

W. J. Hussey. A. S. P. 87. Unusual triple star, components of nearly equal magnitude, forming an equilateral triangle (side 1″·5).

Rev. T. E. Espin. A. N. 3784. Seventy-two new doubles.

R. G. Aitken. A. S. P. 82. Principal component of Σ 238 found to be a close double.

R. G. Aitken. A. S. P. 86, 83 *Aquarii* found to be a close double.

R. G. Aitken. A. N. 3784. Fourth list of new doubles (109).

F. Küstner. A. N. 3821, 66 new double stars.

Measures of Known Pairs—

R. G. Aitken. A. S. P. 86. Measures of the double Aitken 88. Rapid binary.

F. Küstner. A. N. 3821. Measures of 30 pairs.

R. T. A. Innes. M. N. 1902 April. Cape double star results, 1901.

R. T. A. Innes. *M. N.* 1902 December. Cape double star results, 1902.

Rev. T. E. Espin. *M. N.* 1902 March. Measures of Σ 484 and Σ 485.

Rev. T. E. Espin. *M. N.* 1902 May. Micrometer measures of double stars with the 17¼-inch reflector.

E. A. Boeger. *A. J.* 522. Measures of 70 pairs, mostly Σ, made with the 12-inch Washington refractor.

Dr. Jedrzejewicz. *A. N.* 3802. Measures of 25 Struve pairs made in 1887.

John Tebbutt. *M. N.* 1902 April. Micrometer measures of double stars made at Windsor, N.S.W.

E. E. Barnard. *M. N.* 1902 March. Micrometrical observations of Nova *Cygni*.

H. Thiele. *A. N.* 3837. Measures of 41 pairs by photography, distances ranging from 1″·11 to 10″·99.

Royal Observatory, Greenwich. *M. N.* 1902 March. Results of micrometer measures of 400 stars made with the 28-inch refractor in 1901.

W. Doberck. *A. N.* 3798–99. Measures of double stars made at Hong Kong in 1901 and part of 1902.

W. H. Maw. *M. R. A. S.* vol. liv. Double star measures made 1899 to 1901 with 6-inch and 8-inch refractors.

Calculation, &c.—The following papers dealing with calculation and general literature have appeared in the course of the year :

β 151 ...	R. G. Aitken, *A. S. P.* 86. Orbit, period 27·66 years.
Σ 1757, Σ 1785 Σ 1837, Σ 1863	T. Lewis, *Obs.* No. 320. Discussion of measures and general notes on.
Σ 1883, Σ 1989 Σ 2021, Σ 2052 Σ 2402, Σ 2434	T. Lewis, *Obs.* No. 321. Discussion of measures and general notes on.
Σ 2900, Σ 2944 Σ 3041, Σ 3050	T. Lewis, *Obs.* No. 324. Discussion of measures and general notes on.
θ Orionis ...	F. Comas Solá, *A. N.* 3793. Note on and measures of.
η Geminorum	Miss A. M. Clerke, *Obs.* 324.
,,	W. Campbell, *L. O. B.* 20. Variable motion in line of sight.
ζ Herculis ...	W. Campbell, *L. O. B.* 20. Variable motion in line of sight.
,,	P. Lowell, *A. J.* 527, ditto.

W. Hussey. *Obs.* No. 322. "On the measurement of close double stars."

L. de Ball. *A. N.* 3774. "On the influence of parallax, aberration, P.M., and refraction on the position-angle and distance of two fixed stars."

Gavin J. Burns. *B. A. A.* Vol. xii. No. 6. "Distribution of double stars in space."

Dr. Doberck. *A. N.* 3791. "The distribution of Binary Stars."

E. Holmes. *B. A. A.* Vol. xii. No. 7. "Distribution of double stars in space."

Variable Stars.

Since the last report the following twenty-three new variable stars have been announced :

	Provisional Notation.		R.A.	Decl.	Epoch.	Discoverer.	Reference &c.
			h m	° ′			
97	1901	Velorum	9 24·8	−51 38	1875	Cape	Ann. Report
98	1901	Carinæ	11 14·2	−61 10	1875	„	„
99	1901	Capricorni	20 25·3	−22 7	1875	„	„
1	1902	Cygni	20 50·4	+29 53	1855	Williams	*A. N.* 3771
2	1902	Lacertæ	22 41·8	+54 24	1855	Backhouse	„ 3792
3	1902	Monocerotis	6 50·6	+ 6 21	1855	Mme. Ceraski	„ 3775
4	1902	Geminorum	7 32·6	+20 45	1855	„	„ 3782
5	1902	Lyræ	18 56·2	+37 19	1855	Williams	„ 3783
6	1902	Draconis	18 5·1	+65 57	1900	Greenwich	*M. N.* Mar. 1902
7	1902	„	18 6·9	+66 9	1900	„	„
8	1902	Camelopardi	5 49·4	+74 31	1900	„	„
9	1902	Nil					*A. N.* 3799
10	1902	Cygni	21 55·2	+43 52	1900	Harvard	*H. C.* 65
11	1902	Lyræ	19 7·6	+41 4	1855	Williams	*A. N.* 3796
12	1902	Pegasi	22 5·2	+13 50	1855	Graff	„ „
13	1902	Lyræ	19 10·8	+32 10	1855	Williams	„ 3811
14	1902	Persei	2 30·8	+41 34	1855	„	„ 3820
15	1902	Delphini	20 34·7	+11 21	1855	Anderson	„ 3821
16	1902	„	20 26·0	+16 57	1855	Mme. Ceraski	„ 3830
17	1902	Lyræ	18 40·8	+43 29	1855	Williams	„ 3831
18	1902	Coronæ	16 10·3	+38 8	1855	Anderson	„ „
19	1902	Pegasi	21 57·8	+34 25	1855	„	„ „
20	1902	Cygni	21 0·7	+45 12	1855	Mme. Ceraski	„ 3833
21	1902	Sagittæ	20 13·8	+20 39	1855	„	„ 3836

Notes.—Nos. 97, 99, 3, 5, 11, 17, 19, 21 :—Long-period variables. No. 1 :—Cluster-type, per. $13^h{\cdot}4$. No. 2 :—Independently found by Graff, *A. N.* 3774. Nos. 6, 7, 8 :—Found during the measurement of the *Carte du Ciel* plates. Nos. 10, 13, 14, 20 :—*Algol*-type variables, No. 10 having the long period of $31^d{\cdot}304$.

The large proportion of new *Algol* type variables is noticeable.

The number of papers containing observations and discussions of variable stars which have appeared during 1902 is very large, some paper or papers having appeared in nearly each number of every astronomical publication. We may mention here that the Commission of the *Astronomische Gesellschaft*, charged with the preparation of a new variable star catalogue, has issued two lists containing the definitive nomenclature and positions of those stars certainly recognised as variable since the appearance of Chandler's third catalogue. The first list contains 194 stars, and appeared in *A. J.* 514 ; the second list of 24 stars is in *A. J.* 524. These lists will also be found in the *A. N.* 3752 and 3809.

The usual very complete ephemerides for 1903 of variable stars have been issued by Prof. E. Hartwig in part 3 of the *V. J. A. G.* for 1902. These include maxima or minima of the variables north of $-23°$ in one table, and south of $-23°$ in another, both arranged according to R.A. Another table gives maxima and minima arranged according to date. A third part is devoted to the heliocentric minima of the *Algol*-type stars, whilst a final table gives the maxima of the *Antalgol*-type variables *Y Lyræ* and *UY Cygni*. Less complete tables, but ample for many observers' purposes, are published in the *Companion* to the *Observatory*, and in the *Annuaire du Bureau des Longitudes*.

The fourth report of the Variable Star section of the British Astronomical Association was issued in 1902 June by Colonel E. E. Markwick, the director of the section ; it is, however, confined to observations of Nova *Persei*.

In October Mr. Packer observed *α Orionis* (*Betelgeuse*) to be brighter than *Capella*. Dr. Copeland circulated the news by an Edinburgh telegram. The announcement excited wide interest, and many observations, visual and photographic, have already been published.

Dr. A. W. Roberts, of Lovedale, C.C., has a paper on 'Certain Considerations regarding *Algol*-variation, with special reference to C.P.D. $-45°$, 4511 in *Proc. Roy. Soc. Edin.* vol. xxiv., part 2. In this paper Dr. Roberts develops and applies a method of finding the dimensions of *Algol*-systems. A paper by Mr. J. Baxendell on "Pogson's Madras Observations" appeared in *A. J.* 520.

In our last report mention was made that Dr. Chandler had announced (*A. J.* 492) that, owing to the pressure of other work, he would not be able to issue a fourth edition of his catalogue of variable stars. The task of preparing a new catalogue has therefore been taken up by a commission of the *Astronomische Gesellschaft*, consisting of Messrs. Dunér, Müller, Oudemans, and Hartwig. A preliminary report has been published by Prof. G. Müller. He remarks that since Chandler's catalogue of some 400 objects was published in 1896 more than 200 new variables have been discovered. It is the Commission's wish to issue—

as for the beginning of a new century—as complete a representation of our knowledge of variable stars as possible. It is, therefore, purposed to divide the catalogue into several divisions :—Part I. will contain only certainly determined variables ; Part II. is for doubtful objects or those requiring further observation ; Part III. will be reserved for variables in star-clusters. It is pointed out that such clusters as ω *Centauri* containing over 100 known variables make such a division very desirable if not absolutely necessary ; Part IV. and last is to be reserved for "New Stars" which are hardly to be reckoned as variables. It is also proposed to add to the catalogue a collection of auxiliary tables which will be useful to variable star observers and calculators, such as a table of Julian days and tables for the reduction to heliocentric time of *Algol*-type variables. It is the intention of the Commission to include no star in their catalogue which, if a photographic variable, has not an amplitude of variation of one whole magnitude, whilst for visual observations the minimum range will be half a magnitude. It will only be in quite exceptional circumstances that variables with a smaller range will be admitted. Even so, it is estimated that the new catalogue will contain between 600 and 650 variable stars. In Chandler's catalogues the notes were necessarily exceedingly brief ; it is the intention of the Commission to make a radical change in this. They purpose not only giving a short history of each star, but a full description of the form of light-curve and its irregularities if any, as well as a complete index to all the published observations and investigations of period &c. which are of any importance. The Commission are aware of the great increase this will make in their work, but believe it will meet with the approval of astronomers. This index will at once show the practical astronomer the state of our knowledge regarding each star, and thus it will be easy to pick out stars requiring further observation. They specially recommend to young astronomers the observation of such stars as require new observations and offer their advice on the choice of such. The catalogue will be printed in the quarto size of the *Astronomische Gesellschaft* publications. The Commission are now busily engaged on the index and the rediscussion of all the old observations, and hope that in a year's time the conclusion of their task will be in view. They are asking the *Astronomische Gesellschaft* for a grant of 2000 marks in aid of the routine work. R. T. A. I.

Stellar Spectroscopy in 1902.

Spectrum of Nebulæ.—Messrs. Scheiner and Wilsing in their paper in *Ast. Nach.* **159**, 181 (abstract in *Astroph. Jour.* xvi. 234) give the results of their determination, by means of a spectrophotometer, of the relative intensities of the three chief nebular lines at wave-lengths 4861, 4959, and 5007 in nine nebulæ ; and

they arrive at the conclusions that (1) in the nebulæ examined the ratio of the brightness of the lines 5007 and 4959 is constant, but (2) that of the lines 5007 and 4861 varies considerably (thus confirming Keeler's results); (3) the hydrogen (4861) line is relatively brighter in the *Orion* nebula than in any of the other nebulæ examined, the intensity ratio of 5007 to 4861 ranging from 40 : 1 in *N.G.C.* 6790 to 11 : 1 in the *Orion* nebula; (4) the question of the constancy of the intensity ratio of the nebular lines in different parts of the *Orion* nebula has not received further definite elucidation by the measures made hitherto. With regard to the last named point it would seem that, in the light of the first three conclusions of Messrs. Scheiner and Wilsing, constancy in a widely extended nebula would be more difficult of explanation than variation. It is to be hoped that the authors may be able to deduce from their observations a first approximation to the brightness of, let us say, the first nebula line 5007 in the various nebulæ which they have examined.

A contribution to our knowledge of the spectrum of nebulæ comes from the Lick Observatory (*Bulletin* No. 19, and *Astroph. Jour.* xvi. 52). Mr. Wright has determined the wave-lengths of 19 of the brighter nebular lines between 3726 and 5007 from observations of four nebulæ.

Spectrum of New Stars.—The following papers have been published relating to *Nova Persei*:

Lockyer	...	*Proc. R. S.* lxix. 354.
Sidgreaves	...	*M. N. R. A. S.* lxii. 137 and 521.
„	...	*Ast. Nach.* **157**, 197.
Von Gothard	...	„ „ **157**, 141.
Merecki	...	„ „ 158, 43.
Love ...	...	*M. N. R. A. S.* lxii. 524.
Wright	...	„ „ lxii. 630.

Classification of Stellar Spectra.—The interesting address made by Professor Schuster to the Royal Philosophical Society of Glasgow is published in the *Proceedings* of that Society. Under the title "The Evolution of Solar Stars" he gives a broad and very suggestive contribution on various points bearing on classification.

The Solar Physics Committee have issued a Catalogue of 470 of the brighter stars classified according to their chemistry at the Solar Physics Observatory, under the direction of Sir Norman Lockyer.

A brief summary of the various systems of classification hitherto proposed is given by Professor G. E. Hale in the New Supplement of the *Encyclopædia Britannica*, vol. 32, under "Spectroscopy."

Velocity in the Line of Sight.—A plan of co-operation between 8 or 10 observatories engaged in spectroscopic determinations of

radial velocity of stars has been inaugurated by the initiation of Professor E. B. Frost, of the Yerkes Observatory, primarily with the view of arriving at definitive values for the velocity of certain selected stars. We may hope that the co-operation, which in the nature of the case is necessarily of an international character, will lead to further developments in a systematic advance in a branch of astronomy which is growing in scope and interest. (*Astroph. Jour.* xvi. 169.)

Mr. Adams gives (*Astroph. Jour.* xv. 214) the velocity of *Sirius* as $-6{\cdot}87$ $^{km}/_{sec}$ at the epoch 1902.06, as determined at the Yerkes Observatory.

Dr. Eberhard (*Ast. Nach.* **157**, 341) has studied the spectrum of the long period variable χ *Cygni* at the Potsdam Observatory, and finds that the shift of the bright lines suggests a velocity of -20 $^{km}/_{sec}$, whilst that of the absorption lines give a velocity of $+2{\cdot}4$ $^{km}/_{sec}$.

Dr. Hartmann (*Sitz. Berlin. Akad.* 1902, p. 237, and *Astroph. Jour.* xv. 287) has by photographic methods determined the radial velocity of three nebulæ whose spectra exhibit bright lines, viz. *G.C.* 4390, *G.C.* 4373, and *N.G.C.* 7027. His results accord well with those of the visual observations made by Keeler in 1890–91.

Dr. Vogel (*Sitz. Berlin. Akad.* 1902, p. 259, and *Astroph. Jour.* xv. 302) has searched for relative motion in different parts of the *Orion* nebula, and finds evidence of its existence. He points out that the differences of velocity found are for the most part smaller than those which Keeler considered detectable in his memorable investigations.

Variable Radial Velocity.—To the list of stars with variable radial velocity several additions have been made in the course of the year :

	α h m	δ ° ′	Period. d	Discovered.	Reference.
ϕ Persei	1 37	+50 11	...	Lick Obs.	Campbell, Lick Obs. *Bull.* 20; *Astroph. Jour.* xvi. 114.
o Persei	3 38	+31 58	4·39	Yerkes Obs.	Adams, *Astroph. Jour.* xv. 214: Vogel, *Sitz. Berl. Akad.* 1902, 1113
ϵ Aurigæ	4 55	+43 40	...	Potsdam	Vogel, *Sitz. Berl. Akad.* 1902, 1068.
η Geminorum	6 9	+22 33	...	Lick Obs.	Campbell, Lick Obs. *Bull.* 20; *Astroph. Jour.* xvi. 114.
δ Libræ	14 56	− 8 8	...	Yerkes Obs.	Adams, *Astroph. Jour.* xv. 214.
ζ Herculis	16 38	+31 47	...	Lick Obs.	Campbell, Lick Obs. *Bull.* 20; *Astroph. Jour.* xvi. 114; Lowell, *Astronomical Jour.* xxii. 190.

	α h m	δ ° ′	Period.	Discovered.	Reference.
α Equulei	21 11	+ 4 50	...	Lick Obs.	Campbell, *Astroph. Jour.* xvi. 114.
β Cephei	21 27	+70 7	...	Yerkes Obs.	Frost, *Astroph. Jour.* xv. 340.
o Andromedæ	22 57	+14 47	...	Lick Obs.	Campbell, *Astroph. Jour.* xvi. 114.

Mr. Newall contributes a note (*M. N. R. A. S.* lxii. 124) on the velocity of α *Persei*.

New Instruments, &c.—A brief popular account, with illustration, of the new Mills reflector and spectrograph is contributed by Professor Campbell to the *Scientific American* for 1902 November 29. An expedition is to be sent from the Lick Observatory with this installation, under the charge of Mr. Wright, to Santiago (latitude 33° S.) for two or three years, and the photographs of spectra obtained in the survey will be sent to the Lick Observatory for measurement and discussion.

It appears, from a contribution to the *Astronomical Journal*, xxii. 190, that spectroscopic work has been begun at the Lowell Observatory.

Professor Scheiner (*Ast. Nach.* **160**, 369) describes a convenient arrangement for giving a comparison line of controllable brightness for measuring faint spectra.

Measurement and Reduction of Observations.—The following contributions have been made to the study of what may be called the right and left personality in measuring photographs of spectra :—

Hartmann, *Ast. Nach.* **155**, 81.
Reese, *Astroph. Jour.* xv. 142, and Lick Obs. *Bull.* No. 15.
Hasselberg, *Astroph. Jour.* xv. 208.

Mr. H. N. Russell (*Astroph. Jour.* xv. 252) has put the analytical method of computing the orbit of a spectroscopic binary into convenient form for taking account of terms of the second and higher order in the eccentricity. Dr. Wilsing (*Ast. Nach.* **134**, 90, 1893) had previously applied the method of developing the observed velocities in trigonometrical series to the investigation of an orbit of small eccentricity, such that terms above the first of the series in e were not required, viz. the orbit of α *Virginis*. Mr. Russell's note indicates how the method may be developed for more general application, not only so far as degree of eccentricity is concerned, but also in cases where observations fail at certain epochs because of peculiarities in the period.

H. F. N.

Star Catalogues.

The Paris Catalogue.—M. Loewy announced to the Academy of Sciences in November last the completion of this catalogue. The observations extend from 1837 to 1881, and comprise 387,474 observations in right ascension and 221,369 observations in declination of 34,733 stars, and have taken M. Gaillot and M. Bossert twenty years to complete. The first volume $0^h - 6^h$ R.A. was published as far back as 1887.

Dr. N. M. Kam's Catalogue.—Some years ago Dr. Kam brought out a catalogue of stars the observations of which had been made in connection with the observations of comets and small planets &c., and had been published in various periodicals, notably in Band 1–66 of the *Astronomische Nachrichten.* This is a second catalogue, on the same lines as the first, based on similar observations published from time to time in Band 67–112 of the *Astronomische Nachrichten.* A great deal of human interest attaches to this volume. Only about a third of it was set up in type when Dr. Kam, after a short illness, died in March 1896; the rest of it has been completed under the direction of Professor H. G. van de Sande Bakhuyzen as a labour of love for his departed friend. The catalogue comprises 6460 stars brought up to the epoch 1875, with annual variation, secular variation, and the value of the third term, and a comparison wherever possible with some catalogue place.

Leiden Catalogue.—This is one of the catalogues brought out under the auspices of the Astronomische Gesellschaft, and consists of 10,239 stars between north declinations 27° 50′ and 35° 10′. The observations were made in the years 1870–1876 and 1880–1898. In the introduction is a discussion of the personal equation of the various observers for magnitudes, and at the end of the catalogue are tables of comparison with Lalande, Bessel, Struve, and Argelander. The publication of this catalogue now leaves only Dorpat to complete the original survey of the northern hemisphere as undertaken by the Astronomische Gesellschaft.

Catalogo di declinazioni medie pel 1900·0 *di* 1419 *stelle comprese nell' emisfero nord, osservate al circolo meridiano negli anni* 1895–99 *di A. Di Legge e F. Giacomelli.*—This catalogue is of declinations only, made at the Royal Observatory at the Campidoglio, and is remarkable for the fact that the places depend in nearly all cases on as many reflexion as direct observations, the results of both positions being given as well as the mean.

Resultate aus Beobachtungen von 560 *Sternen angeführt in den Jahren* 1897–1901 *am grosser Berliner Meridiankreise, nebst Ableitung der Eigenbewegungen von* 233 *Sternen von H. Battermann.*—This paper contains the computations of the proper

motions of 233 stars, and the catalogue places of 560 stars reduced to 1900·0 from observations made at Berlin between 1897–1901 with the meridian instrument. W. G. T.

Latitude Variation.

'A New Annual Term in the Variation of Latitude, Independent of the Components of the Pole's Motion," is the heading of an article in *A. J.* 517, by Prof. Kimura, or, in other words, the Earth's centre of gravity may have an annual periodic oscillation of a few feet in the line of the axis. The basis of this assumption is as follows :—Professor Kimura, noticing that the residuals of the observations of some of the latitude variation stations showed certain periodicities, recalculated the variation of latitude on the assumption that

$$\phi - \phi_0 = \xi + x \cos \lambda + y \sin \lambda,$$

where ξ is variable with respect to time, but at any particular instant has a constant value for all stations. First of all this was done for ten stations between latitude $60° - 21°$ N. for the period 1899.8—1901.0, secondly from several series of observations in the preceding ten years. The resulting values of ξ for 0·1 of a year from the two discussions are :

Tenths of Year.	ξ (1).	ξ (2).	Tenths of Year.	ξ (1).	ξ (2).
·0	+ ″·031	+ ″·021	·5	− ″·030	− ″·033
·1	+ ·023	+ ·020	·6	− ·033	− ·032
·2	+ ·015	+ ·017	·7	− ·031	− ·015
·3	+ ·002	+ ·006	·8	− ·004	− ·012
·4	− ·015	− ·012	·9	+ ·015	+ ·016

The remarkable accordance between these two determinations would seem to establish the reality of a term ξ the mean value of which will approximately correspond to a mean latitude of 42° N. The high precision of these Küstner-Talcott observations, and the enormous mass of them, precludes the idea that this is anything but an objective reality, and emphasises the fact of the great value of this enterprise, and of what can be done by well directed and concerted action. W. G. T.

The Astrographic Chart.

There are few circumstances to specially record in connection with the work of the Astrographic Chart and Catalogue. The first volume of the Catalogue of the zone allotted to the Paris Observatory has been published during the year, containing the

rectangular coordinates, with the necessary plate constants, of 64,264 stars comprised in a zone two degrees broad whose centre is in declination +24°. M. Loewy has supplemented this publication by some general remarks on stellar photography and the accuracy of photographic measures which have given rise to a discussion which will be found in the *Monthly Notices*. The four French observatories have continued to make reproductions on paper by heliogravure of the Chart plates on a scale twice that of the original ; the numbers of these already published are as follows :—Paris 142, Bordeaux 6, Toulouse 101, Algiers 104. The observatories of Rome and San Fernando are also making enlargements of this kind, and preparations have been made at Greenwich for making similar enlargements by photography.

The state of the work at some of the observatories may be learnt from their annual reports. The third volume of the catalogue of the Potsdam Observatory is in the hands of the printer. The rectangular coordinates of the first volume, which comprises half of the Greenwich zone, is printed but not published. The plates taken at the observatories of the Cape of Good Hope, Sydney, and Melbourne are being measured by means of filar micrometers, and it is believed that the measurement at most of the other observatories is proceeding. H. P. H.

Papers read before the Society from March 1902 to January 1903.

1902.

Mar. 14. Note on the "green flash." T. W. Backhouse.
The flash spectrum, Sumatra eclipse, 1901. S. A. Mitchell.
Micrometrical and visual observations of Nova *Cygni* (1876) made with the 40-inch refractor of the Yerkes Observatory. E. E. Barnard.
Anomalous occultations of stars by the Moon. G. W. Hough.
The duration of totality at Navalmoral. C. T. Whitmell.
Note on Professor Turner's recent paper on photographic surveying. H. G. Fourcade.
The magnitude of η *Argûs*, 1900–1902. R. T. A. Innes.
On the variation of *S Carinæ*. A. W. Roberts.
Σ 484 and Σ 485, and two pairs. Rev. T. E. Espin.
Double star observations, 1899–1901. W. H. Maw.
New variable stars found during the measurements for the Astrographic Catalogue at the Royal Observatory, Greenwich. Communicated by the Astronomer Royal.
Results of micrometer measures of double stars made with the 28-inch refractor at the Royal Observatory, Greenwich, in the year 1901. Communicated by the Astronomer Royal.
On periodic orbits in the restricted problem of three bodies. E. T. Whittaker.
Mean areas and heliographic latitudes of Sun-spots in the year 1901, deduced from photographs taken at the Royal Observatory, Greenwich, at Dehra Dûn (India), and in Mauritius. Communicated by the Astronomer Royal.
The parallax and proper motion of Nova *Persei*, from photographs taken at the Royal Observatory, Greenwich. Communicated by the Astronomer Royal.
On the images formed by a parabolic mirror. First paper: the geometrical theory. H. C. Plummer.
Apr. 11. Cape double star results, 1901. R. T. A. Innes. Communicated by H.M. Astronomer.

1902.

Apr. 11. Notes on nebulæ observed at the Royal Observatory, Cape of Good Hope, by J. Lunt and R. T. A. Innes. Communicated by H.M. Astronomer.

Tables of $\frac{1}{2}(\theta + \cos\theta)$, with explanation of use. W. S. Aldis.

On stationary meteor radiants : third paper. H. H. Turner.

Results of double star measures with the 8-inch equatorial at Windsor, New South Wales, in 1901. John Tebbutt.

Note on the green flash at sunset. Major E. H. Hills.

Saturn seen through the Cassini division. C. T. Whitmell.

On the probable motion of some of the small stars in the Dumb-bell Nebula. E. E. Barnard.

On the supposed variability of κ *Persei* and 36 *Persei*, and a comparison of the photographic and visual magnitudes of those stars. W. H. Robinson.

On the relative number of star images photographed on different parts of a plate, and on the performance of various object-glasses in this respect. H. H. Turner.

May 9. Jacobi's Nome (q) in astronomical formulæ, with numerical tables. R. T. A. Innes.

Series in the nebular spectrum, and in the bright-line spectrum of Nova *Persei*. E. F. J. Love.

The spectrum of Nova *Persei*, 1901, on and after September 5. Rev. W. Sidgreaves.

Visual and spectroscopic observations of the Sun-spot group of 1901 May 19–June 26. Rev. A. L. Cortie.

Reduction of extra-meridian observations of planets. P. H. Cowell.

Measures of double stars with the $17\frac{1}{4}$-inch reflector. Rev. T. E. Espin.

On the accuracy of photographic measures. Second note. H. C. Plummer.

June 13. Discovery of Comet Brooks, 1902. W. R. Brooks.

Observations of *Jupiter* made at Mr. E. Crossley's Observatory, Bermerside, Halifax, during the months of July, August, and September 1901. J. Gledhill.

Further observations of the new star in *Perseus*. A. Stanley Williams.

A dark reticle. C. S. Howe.

On the distribution of the stars in the Cape Photographic Durchmusterung. A. M. W. Downing.

Observations of the total eclipse of the Moon, 1902 April 22, at Perth Observatory, Western Australia. W. E. Cooke.

Ephemeris for physical observations of *Mars*, 1902–3. A. C. D. Crommelin.

1902.

June 13. Reductions of photographs of Swift's Comet (a 1899) taken at Cambridge Observatory with a portrait lens. L. N. G. Filon.

On the principle of the arithmetic mean. H. C. Plummer.

Observations of Nova *Persei*. T. W. Backhouse.

Comparison of Groombridge's and Struve's right ascensions of close circumpolar stars. W. G. Thackeray.

Experimental reduction of photographs of *Eros* for the determination of the solar parallax. Second paper : Combination of results from Mount Hamilton, Minneapolis and Cambridge. A. R. Hinks.

Further observations of the new star in *Perseus* made at the Radcliffe Observatory, Oxford. Communicated by the Radcliffe Observer.

Nov. 14. On the mean distance of a planet, as a function of three heliocentric distances and the observed times. Shin Hirayama.

On the general solution of Laplace's equation and the equation of wave motions, and on an undulatory explanation of gravity. E. T. Whittaker.

Observations of Comet Tempel$_2$ (1899 IV.) made at the Radcliffe Observatory, Oxford. Communicated by the Radcliffe Observer.

Observations of *Saturn*, 1900 July 17, made at Perth Observatory, Western Australia. Communicated by W. E. Cooke.

Old Cape records of Comets. Communicated by R. T. A. Innes.

On Mr. Love's formula for the wave-lengths of nebular lines. W. H. Wright.

On the place of a star near the variable *RU Herculis*. F. A. Bellamy.

Another form of micrometer for measuring star positions on photographic plates. H. C. Russell.

Observations of the satellite of *Neptune* from photographs taken at the Royal Observatory, Greenwich, from 1902 January 6 to April 10. Communicated by the Astronomer Royal.

Ephemeris for physical observations of the Moon for 1903. A. C. D. Crommelin.

Stereoscopic pictures of Perrine's Comet. Max Wolf.

Sur la précision des mesures photographiques. Réponse à deux notes de M. H. C. Plummer. M. Lœwy.

On the images formed by a parabolic mirror. Second paper : Influence on the measurement and reduction of a photograph. H. C. Plummer.

1902.

Nov. 14. Sir W. Herschel's observed nebulous regions, 52 in number, compared with Isaac Roberts's photographs of the same regions taken simultaneously with the 20-inch reflector and the 5-inch Cooke lens. Isaac Roberts.

Newcomb's Fundamental Catalogue : notes and errata. W. G. Thackeray.

On a suggestion made by Sir David Gill that the brighter stars are as a whole rotating with respect to the fainter stars as a whole. H. H. Turner.

Note on photographs of Comet *b* 1902 Perrine, taken at the Royal Observatory, Greenwich. Communicated by the Astronomer Royal.

Note on a comparison of Groombridge's Catalogue (1810) with the Greenwich Second Ten-year Catalogue (1890), with reference to the question of an apparent rotation of the brighter stars as a whole with respect to the fainter stars. Communicated by the Astronomer Royal.

Expedition for ascertaining the best location for Observatories. Percival Lowell.

A standard scale for telescopic observations. Percival Lowell.

Dec. 12. On the accuracy of photographic measures. Third note : Reply to M. Loewy. H. C. Plummer.

Ephemeris for physical observations of *Jupiter*, 1903-4. A. C. D. Crommelin.

Cape double star results, 1902, by R. T. A. Innes. Communicated by H.M. Astronomer.

On Jacobi's method of facilitating the numerical solution of equations arising in the theory of secular perturbations. H. C. Plummer.

Note on binding together réseaux and plates. J. A. Hardcastle.

Cometary observations made at the Liverpool Observatory. W. E. Plummer.

Some developments in terms of the Mean Anomaly. R. T. A. Innes.

Note relating to the preservation of negatives. F. A. Bellamy.

Photographic and visual magnitudes of *α Orionis*. W. H. Robinson.

1903.

Jan. 9. Preliminary note on the possible existence of two independent stellar systems. F. A. Bellamy and H. H. Turner.

New double stars detected with the $17\frac{1}{4}$-inch reflector during the year 1902. Rev. T. E. Espin.

1903.

Jan. 9. On the Sun's stellar magnitude and the parallax of binary stars. J. E. Gore.

A graphical method of applying to photographic measures the terms of the second order in the differential refraction. A. R. Hinks.

Note on plate constants. F. W. Dyson.

Note on the use of Mr. Aldis's Tables of the function $\frac{1}{2}(\theta + \cos\theta)$ in determining the elements of an orbit. H. C. Plummer.

Note on photographs of Comet *d* 1902 Giacobini, taken at the Royal Observatory, Greenwich. Communicated by the Astronomer Royal.

Statistics of stars in a zone of 5° from +65° to +70° Decl., counted on photographs for the Astrographic Chart and Catalogue at the Royal Observatory, Greenwich. Communicated by the Astronomer Royal.

Note on the reproduction and publication of the photographs for the Astrographic Chart taken at the Royal Observatory, Greenwich. Communicated by the Astronomer Royal.

Observations of occultations of stars by the Moon made at the Royal Observatory, Greenwich, in the year 1902. Communicated by the Astronomer Royal.

List of Public Institutions and of Persons who have contributed to the Library, &c., since the last Anniversary.

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Bonn, Royal Observatory.
Bordeaux, Society of Physical and Natural Sciences.
Boston, American Academy of Arts and Sciences.
Breslau, Royal University Observatory.
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Brussels, Royal Academy of Sciences of Belgium.
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Calcutta, Asiatic Society of Bengal.
Canada, Department of Marine.
Canada, Geological Society.
Canada, Royal Society.
Cape of Good Hope, Royal Observatory.
Cape Town, South African Philosophical Society.
Catania, Italian Spectroscopic Society.
Catania, Royal Observatory.
Cherbourg, National Society of Sciences.
Chicago, Academy of Sciences.
Christiania, Society of Sciences.
Copenhagen, Royal Danish Academy of Sciences.
Cordoba, Argentine Meteorological Office.
Cracow, Academy of Sciences.
Egypt, Survey Department.
Geneva Observatory.
Geneva, Society of Physics and Natural History.
Georgetown College Observatory.
Göttingen, Royal Observatory.
Göttingen, Royal Society of Sciences.
Halle, Imperial Leopold-Caroline Academy.
Harvard College Astronomical Observatory.
Helsingfors, Society of Sciences of Finland.
Hobart, Royal Society of Tasmania.
Hong Kong Observatory.

India, Survey Department.
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Kalocsa, Haynald Observatory.
Kasan, Imperial University.
Kodaikanal Observatory.
Leipzig, Astronomical Society.
Leipzig, Royal Society of Sciences of Saxony.
Lick Observatory.
Lund, Astronomical Observatory.
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Madrid, Royal Academy of Sciences.
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Manila, Philippine Weather Bureau.
Mauritius, Meteorological Society.
Mauritius, Royal Alfred Observatory.
Melbourne, Government Observatory.
Missouri University, Laws Observatory.
Moncalieri Observatory.
Montpellier, Academy of Sciences.
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Moscow, Imperial Society of Naturalists.
Munich, Royal Bavarian Academy of Sciences.
Naples, Royal Academy of Sciences.
Natal Observatory.
New York, Columbia University Observatory.
Northfield, Minn., Carleton College Observatory.
Odessa Observatory.
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Ottawa, Literary and Scientific Society.
Paris, Academy of Sciences.
Paris, Astronomical Society of France.
Paris, Bureau of Longitude.
Paris, Dépôt of Marine.
Paris, International Astrophotographic Congress.
Paris, Mathematical Society of France.
Paris Observatory.
Paris, Philomathic Society.
Paris, Society of Physics.
Perth Observatory, Western Australia.
Philadelphia, American Philosophical Society.
Philadelphia, Franklin Institute.
Philadelphia, University of Pennsylvania.
Pola, Imperial Hydrographic Office.
Poona Observatory.
Potsdam, Astrophysical Observatory.
Potsdam, Central International Geodetic Bureau.
Potsdam, Royal Prussian Geodetic Institute.
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Prague, Royal Bohemian Academy of Sciences.
Pulkowa Observatory.
Rio de Janeiro Observatory.
Rome, Italian Society of Sciences.
Rome, Observatory of the Roman College.
Rome, Royal Academy *dei Lincei.*
Rome, Vatican Observatory.
San Fernando, Observatory of Marine.
San Francisco, Astronomical Society of the Pacific.
Sydney, Royal Society of New South Wales.
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Tacubaya, National Astronomical Observatory.
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Turin, Royal Academy of Sciences.
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United States Department of Agriculture.
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Upsala, Royal Society of Sciences.
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Zürich Observatory.
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ADDRESS.

Delivered by Professor H. H. Turner, on presenting the Gold Medal of the Society to Professor Hermann Struve.

By the award of the Gold Medal to Professor Hermann Struve for his work upon the satellites of *Saturn* the Council have recognised by the highest means in their power the great value and importance of his contributions to our knowledge of the Saturnian system. It will be seen from the account which I now proceed to give of Professor Struve's researches that they combine in a remarkable manner great observational skill and perseverance with difficult and complicated mathematical analysis and numerical reductions. Professor Struve's earlier observations, which were made with the 15-inch refractor at Pulkowa, were published, together with the investigations derived from them, in a supplement to the Pulkowa observations in 1888.* The later and more elaborate series of observations were made with the 30-inch refractor at Pulkowa: they were published with a very full discussion in a separate volume of the Pulkowa publications in 1898.† These two volumes contain an immense amount of material relating to *Saturn's* system, and also a complete account of the methods by which Professor Struve has himself derived from them so many results of the highest value and interest. During the progress of the work several papers containing the principal results as they were obtained were published in the *Astronomische Nachrichten*.

When Asaph Hall began to observe with the 26-inch refractor at Washington in 1875 the satellites of *Saturn* were some of the first objects which claimed his attention; and in the years 1875, 1876, and 1877 he made a series of observations of the differences of right ascension and declination of the planet and its most distant satellite, *Iapetus*. The mean distance of the satellite determined from such observations depends mainly upon the differences of right ascension; and as this mean distance is the principal factor in determining the mass of the planet, we thus obtain a calculation of this mass, which is practically free from

* Beobachtungen der Saturnstrabanten. Erste Abtheilung. Beobachtungen am 15-zölligen Refractor. Supplément I. aux observations de Poulkova. 1888.

† Beobachtungen der Saturnstrabanten am 30-zölligen Pulkowaer Refractor. Publications de Poulkova. Série II. tom. xi.

the error of the micrometer screw. The value of the mass of *Saturn* so obtained was published by Asaph Hall in the *Monthly Notices* for 1883 November. It is considerably greater than Bessel's value,* derived from observations of *Titan*, and it was the discrepancy between these two determinations which first directed Hermann Struve's attention to the satellites of *Saturn*. The difference was about 6 parts in 1000, and could only arise from systematic errors in one or both of the series of observations; and it occurred to Hermann Struve that the cause of such errors was probably to be found in the difficulty of connecting the satellites with the planet's disc. He decided, therefore, to depart from the usual method of observations, and, in accordance with a suggestion previously made by his father, to measure the distance of one satellite from another. This meant a considerable addition to the labour of reduction, for in each equation he was liable to twelve unknown quantities instead of the usual six which represent the elements of a single orbit; and anyone who has used the method of least squares knows how rapidly the numerical work increases as we add to the number of unknowns. But our Medallist was not one to shrink from labour if he could secure material improvement; and after satisfying himself by a few preliminary experiments § that the method was promising, he set out unhesitatingly on the gigantic task which is now happily accomplished.

He began with the outer and brighter satellites, which were easier to observe. At the two oppositions of 1884–5 and 1885–6 he compared the positions of *Iapetus* and *Titan* on 93 nights, *Titan* and *Rhea* on 72 nights, *Rhea* and *Dione* on 39 nights. Each comparison involved several observations, and gave two equations with 12 unknowns for correcting the elements of the orbit; though, by assuming the orbits of *Rhea* and *Dione* to be sensibly circular, the 12 unknowns were reduced in some cases to 9. The mere statement of these equations involves 25,000 figures, which may give a vague idea of the total amount of work involved in their formation and solution by least squares. The solution was performed twice over—once with all generality and the second time assuming the relation between the mean distances of each pair given by Kepler's Third Law—and the observations of the two oppositions were kept separate. When it was seen from the accordance of the results that there were no outstanding questions to be answered, the solution was repeated, using all the material to the best advantage. Moreover these solutions were not mere pieces of computing, but were watched

* Bessel's value was $\frac{1}{3501{\cdot}6 \pm 0{\cdot}77}$. Asaph Hall's value in the *Monthly Notices*, vol. xliv. p. 7, is $\frac{1}{3482{\cdot}2}$, differing but slightly from his final value $\frac{1}{3481{\cdot}3 \pm 0{\cdot}54}$. ("The orbit of *Iapetus*," Washington, 1885.)

† *Astro. Nachr.* No. 2641–2.

throughout by the keen eye of a man who knew when there was a theoretical weakness in the separation of two different elements. Struve next determined the perturbations due to the Sun, to the non-spherical shape of *Saturn* and his ring, and to the satellites themselves ; and thus finally obtained corrected elements of the orbits of these four satellites, *Iapetus*, *Titan*, *Rhea*, and *Dione*, for the epoch 1885.

He then returned to the perturbations just mentioned. To calculate these we must assume values for the masses of the satellites and of the non-spherical portion of *Saturn*, and since some of the perturbations are cumulative, any error in these assumed values will become manifest with lapse of time. Having now got a set of good elements for 1885, he compared them with old observations from 1787 onwards, and deduced improved values for the secular changes due to the perturbations. Thence it was but a step to determine the mass of *Titan* and the non-spherical portion of *Saturn* with considerable accuracy, the influence of the other satellites compared with these being too small to give good values of their masses. For *Titan* he found the value $\frac{1}{4678}$ of that of *Saturn*. Four years previously Newcomb had deduced the value of $\frac{1}{10000}$ from a beautiful piece of work on the motion of *Hyperion* ; and Tisserand had arrived at a similar result by two independent methods. Mr. Ormond Stone, on the other hand, showed cause why both these determinations should be corrected to about $\frac{1}{1200}$,* so that there was considerable uncertainty in this element when the work of our Medallist appeared. Almost simultaneously with it, however, G. W. Hill† found from *Hyperion* the value $\frac{1}{4714}$, and soon afterwards Mr. Ormond Stone* found numerical errors in each of the other determinations which brought them into satisfactory accordance with those of Struve and Hill, so that order was evolved out of chaos in a sudden and remarkable manner.

In this first memoir there is also a determination of the mass of the spheroidal excess with the ring-system ; but this was revised in the second memoir and may be passed over for the moment. But there is still one very important result of the first series of observations which calls for notice, namely, the determination of the mass of *Saturn*. The mass of any planet compared with that of the Sun follows immediately from the observation of two things : first, the period in which a satellite of the planet revolves round it ; secondly, the mean distance at which it revolves. Now given a sufficient lapse of time there is never any difficulty about the first of these ; by watching a large enough number of revolutions, even rough observations at the beginning and end will give an accurate value of a single period. The real difficulty is with the second factor, the mean distance, or, say for simplicity, the greatest distance at which the

* *Bulletin Astronomique*, tom. v. p. 350.
† *Astronomical Journal*, No. 176.

satellite is seen from its primary. It is humiliating to think that at the present time we cannot measure a distance of 500″ by differential transits within 0″·5, and yet this is actually the case. The values for the mass of *Saturn* found by Bessel and Asaph Hall, quoted at the beginning of this Address, differ by 6 parts in 1000, which corresponds to a difference of 2 parts in 1000 in the distance, or about 1″·0. The work of our Medallist supports Bessel's value on the whole, bringing it rather nearer, however, to that of Asaph Hall; and the latter repeated his observations on *Iapetus* in 1890, with the result of approximating slightly towards Bessel. But the discordance obstinately refuses to be reduced below 0″·5. In his second memoir Struve gives (p. 239) as a final result 1/3495·3; and Asaph Hall's final result is 1/3485·7, leaving half of the original discordance still unexplained. (In 1885–7 Asaph Hall, jun., found the value 1 3501 with the Yale heliometer.) Probably some form of "personal equation" is responsible for the discrepancy. We are familiar, for instance, with errors of transit arising from differences in brightness: if we measured the distance between a bright star and a faint one by observing the interval between their transits, we should not expect to get a correct result without applying a correction for "magnitude-equation," which would be of different sign according as the bright or the faint star came first. If they could alternate in precedence (as a satellite and its primary do), we could get the correct distance from the mean of a pair of observations without knowing or applying the magnitude-equation. For errors of this kind we should naturally be prepared in the case of comparisons, by transit, of a brilliant planet with its satellite; and it is easy to recognise that Asaph Hall's observations at least are affected in this way;* for the residuals systematically change with the relative distance of planet and satellite. But this will not explain distances being observed too small whether the satellite is east or west of the planet. For this one or other of two suppositions must be made: the first is that the second transit is always observed too soon, whether it be of *Saturn* or the satellite. In micrometer work we are familiar with such errors; for instance, in his micrometer observations of the inner satellites Struve found that his measures of distance differed systematically from those of his assistant; and following up the matter he measured the relative distances *ab*, *bc*, *cd* of four stars *a*, *b*, *c*, *d* in a line, and compared their sum with the total distance

* If we take, for instance, the observations in *Astronomical Journal*, No. 253, and group the residuals together for which the difference of transit was greater or less than 30ˢ, we get

over $+30^s$	$v = -0''.24$	over -30^s	$v = -0''.37$
under $+30^s$	$v = +0''.21$	under -30^s	$v = +0''.18$

The earlier observations in 1875–7 are similarly affected to less degree.

ad, concluding that his own single measures were too small by 0″·088. Even in differential transits cases of the same kind have been found; for instance, in finding the value of a revolution of the screw of a double-image micrometer the screw is turned so that two images of a star are separated by a given interval which is measured by differential transits; and it is generally found that the deduced screw-value varies with the separation, pointing to some systematic error in measuring distances by transits. The error is only large, however, when the two images are very close, and we should scarcely expect to find a sensible error of this kind in the case of objects separated so widely as *Saturn* and *Iapetus*. A second possible supposition is that the difference in brightness of *Iapetus* at Eastern and Western elongation, which amounts to fully two magnitudes, is responsible for the discrepancy. But in either case we must admit that such errors are also likely to affect the relative distance of *Titan* and *Iapetus*, so that the method of Struve would not be *in this case* freer from suspicion than that of Asaph Hall. For the present, while recognising the great merit of Struve's work, we can merely place his result for the mass of *Saturn* alongside of that of Asaph Hall, awaiting further light on this most difficult puzzle, which will perhaps come from further heliometer measures.

Let us now turn to the second series of investigations. The second memoir is nearly three times as long as the first, and probably represents at least three times as much work. Figures are apt to be wearisome, and I must not give too many; but some figures are necessary in order to convey any idea of the marvellous diligence of our Medallist; while to appreciate it properly is no doubt impossible unless one has laboured in the same field. Most of us can understand, however, that considerable labour is necessary for the computation of a single orbit: Struve makes 14 determinations of the orbit of *Rhea*, 14 of *Tethys*, 7 of *Enceladus*, 6 of *Hyperion*, 5 each of *Mimas* and *Dione*, and 2 of *Titan*—53 orbits in all—and this is of course only a fraction of his work. Before it came all the observations, made with his own eyes; after it came an elaborate discussion of the changes in the orbits, leading to results to be presently mentioned.

The observations are certainly beautiful. Taking the system *Tethys-Rhea*, the probable error of a single observation comes out from solutions in seven successive years ±0″·056, ±0″·059, ±0″·059, ±0″·064, ±0″·069, ±0″·069, and ±0″·066. Any other sets might be substituted for these. It is scarcely conceivable that an observer should have a more uniform habit than this, and it is doubtful whether any of the great visual telescopes of the world has ever been, or ever will be, used to better purpose. There are 1300 of these beautiful observations, and the mere statement of the equations for reducing them, which in the last volume ran to 25,000 figures, now requires over 100,000. The total work must have needed millions. Comment is not only

difficult but superfluous ; and we will pass to the more noteworthy of the results, especially the unforeseen results, of all this eminently skilled labour.

The first has reference to the position of *Saturn's* equator. Before Struve's work this had been taken to coincide approximately with the plane of the orbits of the satellites, and there was no accurate knowledge of any real differences, which are certainly small. But if the orbit plane of any satellite is inclined to the plane of *Saturn's* equator, it follows from the theory of perturbations that the inclination will remain constant, though the plane will revolve with constant angular velocity, assuming that the spheroidal shape of *Saturn* is the chief perturbing cause. Struve found that he could choose the plane of *Saturn's* equator, so that the orbit of *Tethys* was inclined to it at a constant angle of 65′·1, while its plane revolved with a uniform velocity of 72°·8 per year ; and the orbit of *Rhea* was inclined to it at an angle of 20′·5, revolving at a rate of 10°·2 per year. In fact he detected the true position of *Saturn's* equator for the first time, and gave a precision to his result which led him to a discovery of a remarkable kind, as we shall presently see. To follow, however, the course of events, he determined the eccentricities and motions of the apsides of *Enceladus* and *Dione* ; and not only a large eccentricity, but a considerable inclination for the orbit of *Mimas*.

Now we have seen that Struve calculated the orbits of all these satellites, not only once, but several times ; and he was able to detect, therefore, not only the values at a single epoch of all these eccentricities and inclinations, many of which he discovered for the first time, but the changes in them from epoch to epoch. In this way, as has just been mentioned, he found the rate at which the planes of the orbits of *Tethys* and *Rhea* were revolving on the plane of *Saturn's* equator. He also found—

1. That the Perisaturnium of *Enceladus* is revolving at such a rate that the conjunctions of *Enceladus* and *Dione* always occur in that direction. This actual result was new, but a similar result had been already found by Newcomb in the case of *Titan* and *Hyperion*, and shown to follow from the near commensurability of the mean motions.

2. But in the case of *Mimas* and *Tethys* Struve found a law of perturbation which had not been anticipated even by analogy. The conjunctions of these two satellites oscillate about the direction midway between the *ascending nodes* of these orbits on the plane of *Saturn's* equator. This is the remarkable discovery above referred to ; for it is needless to point out that it could not have been made unless he had first determined the plane of *Saturn's* equator with great precision. And there were further important consequences. The motion of *Mimas* and *Tethys* had long been a puzzle. Marth had recognised that the mean motion of *Mimas* was variable and had taken refuge in the hypothesis of a secular acceleration, and Dr. Bohlin had found, from the dis-

cussion of old observations, that there were changes in the mean motion of *Tethys*. The reason of both these anomalies was now explained by the oscillation or libration of the line of conjunctions, which gave, in fact, a long inequality of seventy years' period and considerable amplitude. Since these curious perturbations have coefficients depending on the masses of the tiny satellites, it was possible to find the masses of *Mimas*, *Tethys*, and *Dione*; and upper limits for those of *Enceladus*, *Rhea*, and *Iapetus*; and it appears that the masses found in this way are smaller than would be expected from the brightnesses compared with that of *Titan* in a ratio which becomes more pronounced as we approach the planet—viz. the masses of *Rhea* and *Dione* are about seven times, *Tethys* thirteen times, and *Mimas* as much as twenty-six times, smaller than the brightness would suggest. Either the density of the inner satellites is much less or their albedo much greater than that of the outer, and this is in accordance with what is known of *Jupiter's* system.

We cannot sufficiently admire the skill with which our Medallist proceeds from one discovery to another, making each secure and complete as he goes, so that it may serve as a sure stepping-stone to the next. From his beautiful observations he calculates a series of orbits, which can only be reconciled by rectifying the plane of *Saturn's* equator; thence he proceeds to the changes of the orbits; and though some of these are quite novel in character, he unravels them with the same ease with which he made the observations. Thence he steps to the masses of the tiny satellites; and finally to an approximate law of physical relationship which may ultimately throw light on the remote history of the Saturnian system. All this with a facility and elegance which make it clear that he is a complete master of all his weapons, from the giant 30-inch telescope to the complexities of gravitation analysis.

And I have by no means completed the list of his achievements. He found also the compression of the body of the planet from the perturbations of the satellites, and his result was in good accordance with the compression derived from measures of its shape. He found that the Ring could not have a mass much greater than that of one of the satellites, which affords a fresh confirmation of the correctness of Clerk-Maxwell's views with regard to the constitution of the Ring. If we were tempted for a moment to wonder whether the story so beautifully unfolded by our Medallist belonged to the regions of romance rather than of solid fact, we should be at once reassured by such independent confirmations as these. It has already been remarked how his value for the mass of *Titan*, which at the time of publication seemed far indeed from any previous suggestion, was almost immediately confirmed from three independent sources. His observations of *Mimas* and *Tethys* elucidated the difficulties found by Marth and Bohlin. His series of values for the masses of the satellites finds an analogue in the system of the planet

Jupiter, and is a new proof of the unity of the solar system. Two totally independent methods of measuring the ellipticity of *Saturn's* disc are mutually confirmatory ; and finally his value for the mass of the Ring must be associated with the spectroscopic experiment of Keeler as a beautiful and independent confirmation of the work of Clerk-Maxwell thirty years before.

We have still to notice a case where Struve not only confirmed the work of others, but added to it in a striking manner. It had been shown by Newcomb that the conjunctions of *Hyperion* and *Titan* were linked in perpetuity with the Aposaturnium of *Hyperion*. This discovery was, in fact, the prototype of Struve's discovery of a similar relation for the orbits of *Enceladus* and *Dione*, and has already been referred to. In such cases it does not follow that the linkage is absolute ; the conjunctions may librate or swing from side to side of the line of apsides, though they never ultimately depart from it ; but Newcomb had supposed that in the case of *Titan* and *Hyperion* there was no sensible libration of this kind. The searching scrutiny of Struve, however, detected a libration of 640 days' period, which may alter the longitude of *Hyperion* by $\pm 9°$. Let us consider for a moment what this means in the language of our every-day life. Sailors divide the compass into thirty-two "points," each of which is therefore about eleven degrees. It would be regarded as a slight, though sensible, alteration in the course of a ship to sail her a single "point nearer the wind," and viewed from a distance this change, of course, might be difficult to detect. A thousand million miles away a tiny satellite is sailing in its orbit with what might seem like precise regularity ; but the keen vision, optical and mental, of our Medallist detects that every two years it strays about a "point" from its expected position, which he considers a vagary so large that it could not possibly be overlooked ! Such is the advance which astronomical science has made in the three centuries which have elapsed since Galileo first saw that there were other satellites besides our own Moon.

In the years 1890–1892 the ring of *Saturn* closed up to a thin line of light, and measures were made of the ball and rings. Eclipses of the satellites were also observed at Pulkowa and elsewhere, and used to determine the dimensions of the ball by an independent method the accuracy of which can be estimated from the fact that the value of the semi-major axis of the planet at mean distance found at Pulkowa was $8''{\cdot}720$, and at Princeton $8''{\cdot}716$ (*Monthly Notices*, liv. p. 465). Struve neglects no opportunity, as is well exemplified in his treatment of the numbers of old observations of the satellites. To give one instance : Some transit observations of *Iapetus* and *Saturn* were made at Marseilles in 1787, which were published by Lalande and used by him to determine the orbit. But there was obviously something wrong with them. The original records of the observatory before 1792 had been lost, as Asaph Hall ascertained ; and after spending much time in trying to divine some misunderstanding which

would make sense of them, he gave them up as hopeless. Coming later on the field, Struve might well have been content with the verdict of so able an astronomer as Asaph Hall; but he spared no pains to get at the truth. He selected nine of the best observations for reduction, and from a study of the results concluded that the transits must have been observed across a bar inclined at an angle different from that assumed by Lalande.

By this imperfect sketch I hope to have brought before you in some degree the sterling qualities of the work which we are honouring to-day. I hope to have shown that it is of the first order both in quality and quantity; that our Medallist is not only a skilful observer, and an untiring worker, but in the front rank as a mathematician. For this rare combination of qualities in the man himself, and for what he himself has done alone, he receives this token of our highest esteem.

But it is natural that our thoughts should stray from the present occasion to the past; from the man himself to his father, who was awarded our Medal more than half a century ago; and to *his* father, who received it a quarter of a century before that. For the third time we welcome the name of Struve to our list of honour, and a welcome as cordial awaits an unlimited number of those who in the future may produce work of the same quality as their forefathers. On one fact we dwell with especial pleasure: our hearts warm to think that the venerable figure of Otto Struve has been spared to see the day when his son receives this mark of our esteem. All those who formed our Society when he received our medal in 1850 have passed away; but two of our associates—Otto Struve and Johann Gottfried Galle—remain to tell us that devotion to astronomy enables men to defy the march of years. In a letter dated January 13 Otto Struve regrets that infirmities prevent his undertaking the journey from Karlsruhe to England in order to be present at our meeting, but he begs me to greet the Society cordially from him. Our Medallist himself also finds that he cannot put aside his engagements to be present to-day; and while for our own sake we cannot but regret his absence, we recognise in it another instance of that self-denying devotion to duty without which he could not have carried out so successfully and completely this great work.

The Chairman then, handing the Gold Medal to the Councillor of the German Legation, addressed him in the following terms:—

"Count von Bernstorff, we thank you for being present to-day to receive the Medal on behalf of Dr. Hermann Struve. In transmitting it to him we beg you to assure him that this formal recognition of his work is but the natural outcome of the keen interest and appreciation with which it has been followed by the astronomical world for many years past; and that we are glad to think that its value to him will be enhanced by the knowledge that it ranks him with his venerable father and his famous grandfather."

Note added 1903 *February* 1.—In the "Report of the Council of the Society to the First Annual General Meeting, 1821 February 9," there is the following paragraph (*Mem. R.A.S.*, vol. i. p. 25) :—

"The subjects of physical astronomy are so various, and of so mixed and complicated a nature, that the Council defer to a future opportunity their observations on this head. In order, however, to show their disposition to encourage the consideration of such subjects (unhappily too much neglected among the geometers of this country) they recommend the proposal of the Society's gold medal and twenty guineas for the solution of the following prize question :—

> "'For the best paper on the theory of the motions and perturbations of the satellites of *Saturn*. The investigation to be so conducted as to take expressly into consideration the influence of the rings, and the figure of the planet as modified by the attraction of the rings, on the motions of the satellites ; to furnish formulæ (adapted to the determination of the elements of their orbits, and the constant coefficients of their periodical and secular equations) from observation ; likewise to point out the observations best adapted to lead to a knowledge of such determination. The papers to be sent to the Society on or before the 1st day of February 1823.'"

Apparently no reply was received before the specified date ; but after the lapse of 80 years the Gold Medal is bestowed for a complete solution of the problem proposed at the foundation of the Society.

The meeting then proceeded to the election of Officers and Council for the ensuing year, when the following Fellows were elected :—

President.

H. H. Turner, Esq., D.Sc., F.R.S., Savilian Professor of Astronomy, Oxford.

Vice-Presidents.

Sir William Abney, K.C.B., R.E., D.C.L., F.R.S.
J. W. L. Glaisher, Esq., M.A., Sc.D., F.R.S.
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F. W. Dyson, Esq., M.A., F.R.S.
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Foreign Secretary.

Sir William Huggins, K.C.B., O.M., LL.D., D.C.L., F.R.S.

Council.

Sir R. S. Ball, M.A., LL.D., F.R.S., Lowndean Professor of Astronomy and Geometry, Cambridge.
W. H. M. Christie, Esq., C.B., M.A., D.Sc., F.R.S., Astronomer Royal.
A. A. Common, Esq., LL.D., F.R.S.
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Major P. A. MacMahon, D.Sc., F.R.S.
Captain William Noble.
A. A. Rambaut, Esq., D.Sc., F.R.S., Radcliffe Observer.
W. G. Thackeray, Esq.